CREATIVE EVOLUTION IN ARCHITECTURE: A CRITICAL INQUIRY INTO NEW RELATIONS OF OBJECTILE-SUBJECTILE AND INTELLIGENT SPACES

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ABSTRACT

CREATIVE EVOLUTION IN ARCHITECTURE: A CRITICAL INQUIRY INTO NEW RELATIONS OF OBJECTILE-SUBJECTILE AND INTELLIGENT SPACES

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This thesis investigates how architecture has responded to evolutionary changes under the ongoing influences of advanced technologies and industrial revolutions. It considers the evolutionary aspects of human-computer interactions and the built environment in describing the creative evolution in architecture. In the period approaching Industry 5.0, the research relocates the subject of architecture in the context of human-technology relations: novel scientific paradigms and coexisting technological developments offer creative and non-standard production opportunities with new design and production tools for the architect-subject in architectural practice, the majority of which evolved within Industry 4.0. It is claimed that this transformation also implies new thresholds in architectural practice and new organizational dynamics via intelligent spaces and learning environments of scientific and academic institutions, as in smart campuses. Hence, the research aims to study intelligent spaces in the context of evolutionary built environment, design, and recent developments in production, following state-of-the-art technologies, to grasp new relations between Objectile and Subjectile.

In this regard, to define the theoretical boundaries with key concepts for new subject-technology-environment relations, the research applies both content and spatiotemporal analysis to the related research and selected cases. Evaluating Henri Bergson's seminal ideas on creation, creativity, and evolution, the research initially defines the research problem on new Subjectile-Objectile relations. Architectural practices that are dominated by transformed production conditions also include different evolutionary processes depending on certain factors outside the field of architecture itself. The dominant transformation of architectural practice from the first quarter of the 20th century has ultimately reached the present period, with smart spaces, intelligent networks, automation in construction, and new human-computer interactions. In this research, an exploration of the complex modalities between architects, technology, and the built environment through challenging inquiries into the industry, technology, and science is conducted accordingly. In this scope, this research aims to define creative evolution in architecture by considering evolving architect-technology-environment relations. To achieve this aim, the research inspects how artificial (intelligence) neural networks, multi-agent systems, collective models, and crowdsourcing methods can be analyzed, classified, and applied through spatiotemporal examples, architectural practices, and theories. Finally, the thesis evaluates how these investigated methods, abstract models, and research are applied through intelligent spaces, learning environments in scientific/academic institutions and smart campuses in understanding new relations between Objectile, Subjectile, and the built environment.

Keywords: Architecture and Technology, The Digital Paradigm in Architecture and the Built Environment, Objectile and Subjectile, Intelligent Spaces, Universities & Smart Campuses

ÖZ

MİMARLIKTA YARATICI EVRİM: TEKNOLOJİK NESNE [*OBJECTILE*]-ÖZNEL ARAYÜZ [*SUBJECTILE*] VE AKILLI MEKANLARIN YENİ İLİŞKİLERİ ÜZERİNE ELEŞTİREL BİR ARAŞTIRMA

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Bu tez, mimarlığın, ileri teknolojik ve endüstriyel devrimlerin süregelen etkileriyle evirilen değişimlere nasıl yanıt verdiğini araştırmaktadır. Bu araştırma, mimarlıkta yaratıcı evrimi tanımlamakta, insan-teknoloji ilişkilerinde ve yapılı çevrede evirilen unsurları ele almaktadır. Endüstri 5.0'ın yaklaştığı bu dönemde, araştırma mimarlığın öznesini insan-teknoloji ilişkileri bağlamında yeniden konumlandırmaktadır: Yeni bilimsel paradigmalar ve buna koşut teknolojik gelişimler, mimarlık pratiğinde temelde Endüstri 4.0 ile dönüşen yaratıcı ve standart olmayan üretim olanakları ile mimar-özne için yeni tasarım ve üretim araçları sunmaktadır. Bu dönüşümün aynı zamanda mimarlık pratiğinde akıllı mekanlar, bilimsel ve akademik kurumların öğrenen çevreleri olan akıllı kampüsler vasıtasıyla yeni 'yeni eşikler' ve örgütsel dinamikler oluşturacağı ileri sürülmektedir. Bu anlamda bu tez akıllı mekanları, teknolojik nesne (Objectile)-öznel arayüz (Subjectile) arasındaki yeni ilişkileri anlamak için, evirilen yapılı çevre, tasarım ve teknoloji harikalarını takip eden üretimdeki yeni gelişmeler bağlamında ele almaktadır.

Araştırma bu bağlamda, yeni özne-teknoloji-çevre ilişkilerinde teorik çerçeve ve kavramları tanımlamak için ilgili araştırma ve mekânsal durumları içerik ve zamanmekân analizlerine tabi tutmaktadır. Henri Bergson'un yaratım, yaratıcılık ve evrim üzerine fikirlerini değerlendiren bu çalışma, araştırma problemini öncelikle yeni teknolojik nesne (Objectile) ve öznel arayüz (Subjectile) ilişkileri üzerine yöneltmektedir. Dönüşen üretim koşullarına başat mimarlık pratikleri dışsal etmenlere de bağlı olarak farklı evrimsel süreçler içermektedir. 20. Yüzyılın ilk çeyreğinden günümüze kadar uzanan mimarlık pratiğinin teknolojiyle dönüşümü, nihayetinde akıllı mekanlar, akıllı şebekeler, yapıda otomasyon ve insan-bilgisayar etkileşimiyle yeni bir döneme ulaşmıştır. Buna bağlı olarak bu araştırmada, üretim, teknoloji ve bilimdeki zorlu araştırmaları irdeleyen mimarlar, teknoloji ve çevre arasındaki karmaşık ilişkiler üzerine bir inceleme sürdürülmüştür. Bu kapsamda, araştırma evirilen mimar-teknoloji-çevre ilişkilerine bakarak mimarlıkta yaratıcı evrimi tanımlamayı hedeflemektedir. Araştırma bu hedefi gerçekleştirmekte, yapay (zekâ) sinir ağları, çok etmenli sistemler, kolektif modeller ve kitle kaynak kullanım yöntemlerinin, zaman-mekânsal örnekler, mimari pratik ve teorilerle nasıl analiz edilip sınıflandırılarak uygulanabileceğini irdelemektedir. Sonuçta, bu tez teknolojik nesne (Objectile)-öznel arayüz (Subjectile) ve yapılı çevre arasındaki ilişkileri anlamakta ele alınan metot, model ve araştırmaların akıllı mekanlar, bilimsel/akademik kurumlarda öğrenen çevreler ve akıllı kampüslerle nasıl uygulandığını değerlendirmektedir.

Anahtar Kelimeler: Mimarlık ve Teknoloji, Mimarlık ve Yapılı Çevrede Dijital Paradigma, Teknolojik Nesne ve Öznel Arayüz, Akıllı Mekanlar, Üniversiteler ve Akıllı Kampüsler

To My Family

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LIST OF ABBREVIATIONS

ABBREVIATIONS

AI: Artificial Intelligence

AIAA: American Institute of Aeronautics and Astronautics

APM: Atomically Precise Manufacturing

AR: Augmented Reality

BIM: Building Information Modelling

CAD: Computer-Aided Drawing

CAM: Computer-Aided Manufacturing

CERN: The European Organization for Nuclear Research

CFAO: Computer-Assisted Conception and Fabrication

CNN: Convolutional Neural Network

DARPA: The Defense Advanced Research Projects Agency

DNN: Deep Neural Network

GRN: Gene Regulatory Networks

IoT: Internet of Things

LSTM: Long-Short Term Memory

MOOC: Massive Open Online Courses

NASA: National Aeronautics and Space Administration

NIF: National Ignition Facility

PSO: Particle Swarm Optimization

QPSO: Quantum-behaved Particle Swarm Optimization

RNN: Recurrent Neural Network

R&D: Research and Development

SI: The Situationist International Movement

SNN: Spiking Neural Network

VR: Virtual Reality

LIST OF SYMBOLS

SYMBOLS

↑	Arrow (Upwards)
↓	Arrow (Downwards)
=	Equal to
e	Euler’s number
$\otimes$	Functional operation
$>$	Greater than
$\int$	Integral
∂	Partial derivative
π	Pi
$\prod$	Product (Multiplication)
$\sum$	Summation
†	Transpose (Dagger)

CHAPTER 1

INTRODUCTION

1.1. Aim and Question of the Thesis

Architecture has undergone significant evolutionary changes with the rise of the digital paradigm within its practice and theory. Recently, advancements in non-standard production, human-computer interactions, and intelligent environments, aside from the rise of robotic technologies, have been further implemented in architecture via the fourth industrial revolution, or 'Industry 4.0'. The critical concept of Objectile[1], in that regard, has revealed a new complexity in non-standard production outcomes. The rising impact of digital twins with augmented reality, robotic construction, and IoT technologies towards Industry 5.0 has further required the redefinition of Subjectile[2] and new Objectile-Subjectile relations in the challenges relating to decision making and creative action with emerging state-of-the-art technologies and intelligent spaces.

Thus, this thesis explores how architecture has responded to these evolutionary changes in human-artificial interactions, technology, production, and the built environment. With inspiring ideas from Henri Bergson's theories on *Creative Evolution*, the thesis aims to read the changing dynamics in architecture with digital technologies. Bergson's theory on 'creation' is about an ontological understanding of the discrete moment of creation, genesis, and creativity in life's evolutionary dynamics

[1] Bernard Cache defines Objectile as the flowing technological object created by informational technologies in non-standard production (Cache, 1995). In the rise of informational technologies that have enabled the design and production of customized objects digitally, Bernard Cache aims to emphasize the increasing flow of information and its outcome as the technological object by the term 'Objectile'. In this study, Objectile is used to describe the current condition of new technological objects, such as artificial agencies, design products, and nonstandard production, by the advancements in technologies.
[2] Bernard Cache describes 'Subjectile' as creative attributes, as in the ones of curvilinear forms, that subject intuitively generates through production objects like molds (Cache, 1995). Additionally, Subjectile can be described by the tendencies, preferences, and genuine contributions of the subject in its interaction with artificial objects (Cache, 1995). In this regard, new interpretations of Subjectile should be regarded as the creative or performative act or preferences of one individual in connection with non-standard production, as interfaces, objects, and relations that will be generated by new technologies.

(Bergson, 1998, pp. ix-xv; 98-272). Bergson assessed the notion of creativity in human behavior, and he questioned the complex stages, divergent lines, and culminating points of the evolution of multiple ecologies in life (Bergson, 1998). Therefore, his idea about creation is initially interpreted in this thesis to understand creativity's role in the complexity of human-computer interactions, correlations, and architecture's evolutionary progress.

Artificial agents and computational tools in the evolutionary changes of architecture are believed to have the capacities of information creation that architects cannot achieve. The immediate duplication or instant generation of information, faster computations, multitasking capabilities, and discrete and coexisting correlations are among such skills of artificial agents of virtual and substantial creation, in addition to their mechanical capacities. On the other hand, the 'creative impulses' of the human agents perform in harmony with the metabolic processes in life; intuit complex relations in duration (Bergson, 1998, pp. 1-7; 2002), and usually provide subtle distinctions and decisions regarding social, cultural, and collective dynamics.

New generation technologies such as neuromorphic chips, molecular computing, quantum computing, and supercomputers (Arute, Arya, Babbush, et al., 2019) have started to challenge our physical and cognitive worlds. Moreover, the rise of 4D printing, which creatively reproduces, restructures, or regenerates its materiality, has also enabled the interactions of architects and designers with digital interfaces during production[3]. This development implies new relations and ecologies to be creative evolutionary processes in architecture. It is now possible to grasp such evolutionary trajectories of successive industrial revolutions in technological objects towards the non-standard productions, reinterpretation of creativity, and in the redefinition of Subjectile. Accordingly, Objectile-Subjectile relations are in need of fresh explorations with regard to Industry 5.0.

The necessity of shared concepts and even correlations between architect-subjects and technological interfaces for creative action offers a generative mindset[4] to derive new human-artificial models and relations in decision making, action, and production.

[3] Autodesk's Project Cyborg was specifically developed by a team of designers and engineers (Tibbits, 2014).
[4] See also (Bergson, 1911; 1927; 1920; 1946).

Bergson's concept of intelligence described for the intellectual agent in the dynamics of the creative evolution of Life (Bergson, 1998, pp. 135-165), in this regard, is selected as the primary key concept for the (re)conciliation between the natural and artificial agents as the form of intelligence (Bergson, 1998, pp. 186-272). By evaluating Bergson's ideas, this reconciliation can be found in sense perception and in the cognitive functions of the intellect and instincts (Bergson, 1998). Efforts to understand this form of intelligence will hence be attempted with its primary cognitive constituents of performance and Affect, together with content analyses of the related research in cognitive science (Bergson, 1998; 2002; Marcuse, 1998; Picard, 1997; Ballard, 2015; Deamer, 2015b). The related modalities for new Subjectile-Objectile relations are respectively evaluated through key concepts of performance, affect, and intelligence, defining the theoretical boundaries of the primary research question. This inquiry includes the correlational aspects of humans and technology in production, industry, and science, apparently revealing the complex topologies of humankind, nature, and technology in a creative evolutionary process. It requires a new professional organization, and paves the way, as Hight and Perry claimed, to a new 'collective intelligence' (Hight & Perry 2006).

This organization is a novel socio-technological play that incorporates design and action, and human, computer, and environmental forces within a networked relation. The reasoning behind this incorporation explains how particularities can define a collective intelligence around given tasks. The study also questions the evolutionary transformation of the built environment on human-technology-environment relations because of the prominence of the role of the built environment in the organization of those collectivities. Thus, the inquiry into collective forms of peer-to-peer relations between the new Subjectile and Objectile are studied further under the rising impact of intelligent spaces. The development of artificial neural networks and sensorial computational tools towards neuromorphic computer chips also implies new organizational capacities, even for architecture. In this regard, crowdsourcing by Big Data and the Internet of Things (IoT) gain priority in the generation of selections, preferences, and conscious decision making to describe the new role of Subjectile with inevitable repercussions on the future of architectural technologies and intelligent environments.

Accordingly, the ascribed meanings of intelligence, which are again reinterpreted from the book *Creative Evolution* (Bergson, 1998), account for the cognitive togetherness of performative skills, efficiencies, and organizations among architects, artificial agents, and the environment. The scope of this concept of intelligence ranges from material intelligence to the rising paradigm of sensorial environments and spatiotemporalities with crowdsourcing and IoT for the action of the new Subjectile. Thus, this intelligence accompanies the cognitive aspects through affect-based interactions, primarily considering the role of creativity and performances as a couple of relations in the generation of intelligent spaces.

Technology can be the factor that effects the segregation and differentiation in the primary distinctions among the architect, engineer, designer, artist, businessperson, and producer. However, this research claims that the concept of intelligence for organizational capacities can generate unity among different professionals, once again, by technological capacities and interrelated conceptions. This unified attempt questions the sharp distinctions among professions that can come together in shared creative decision-making processes and actions using technology and novel environments (Carpo, 2013). Intelligent spaces, learning environments of scientific and academic institutions, and even smart campuses, in that regard, can be inspected as such spatiotemporalities due to their evolutionary dynamics. This research critically investigates the collective impacts, spatiotemporal outcomes, and consequences of technologies in relation to production, industry, and space through the theoretical conceptions of Objectile and Subjectile.

New generation computing means also have a consequential place in questioning the intelligence of interrelated actions in their spatiotemporalities and the interdisciplinarities of different professions. To be actively used in assessing the performativity and energy-related patterns of architectural technologies, new generation computers, and the future of AI imply overcoming challenges of environment and subjectivity through negentropy-based energy relations. This argument herein necessitates being critically aware of the strategical growth of these technologies. These relations can only be understood, however, within the evolutionary trajectories of the industrial revolutions and discrete reference systems that have emerged in different processes, from modernity to new technological developments.

The current dynamics of the digital paradigm and advanced production technologies also imply a challenge in architecture, as a modern profession, to understand the creative shift, with its repercussions, on agent-based organizational formations, changing collective practices, and spatiotemporal activities. Respectively, these distinct referential bases indicate different paradigmatic turns that can be defined through the creative evolutions in architecture. Therefore, the argumentations with regard to the digital paradigm also require a survey on the historical evolution of architectural mainstreams, including the concern of the discreteness and togetherness of related paradigms about the built environment that we live in and the rising technology that we use. The thesis examines the concepts and paradigms of the modern built environment and the digital paradigm and intelligent spaces together as complex topologies of human-artificial-environment interactions. In this respect, the aim is to unfold the encapsulating dynamics of the architectural profession that shape the built environment we inhabit together with the technologies that we use. This is an attempt to see the possible relations between architects, technology, and the developing intelligent environments.

The above notwithstanding, it is not an easy task to present the complexities of these evolutionary trajectories and topological modalities all at once. The complexities of the topological relations of the architect, technology, and the environment include the rules of nature and the culture of the built environment. Therefore, consistent methodologies of spatiotemporal analyses and overarching content analyses of related research are proposed to classify and reread those complexities through the common mind/skillsets for new relations between Objectile-Subjectile and the environment. By this approach, the aim of the research is to develop a specific theoretical framework for the novel practices of technology in intelligent environments. The investigation aims to provide an understanding of how human-artificial interfaces, technology transfers, multi-agent models, and crowdsourcing methods towards many-body systems of human-artificial-environmental interactions can be evaluated for complex and creative collectivities and modalities in architecture.

Decision-making processes and creative (performative and affect-based) actions are claimed to search for critical intelligence in architecture for these collectivities, many-body systems, and human-artificial-environment topologies with regard to the challenges of knowledge generation. At this point, the research finds a gap in the existing literature to found new Subjectile-Objectile relations that university campuses have seen little discussion in the discourse on the spatiotemporal qualities of collective organizations. Thus, the research seeks new collective modalities between Subjectile and Objectile in the implication of intelligent spaces by research institutes and universities, and in designing spatiotemporalities and producing architectural technologies. The research finally analyzes particular cases from universities and scientific research centers, such as learning and research environments and smart campuses, with collective, institutional, and organizational expectations to implement intelligent spaces in the built environment.

1.2. The Motivation of the Thesis

The influences of technological revolutions have altered the focus of architecture from being a modern discipline to the influences of artificial intelligence and new technologies on design and cognition (Mitchell, 1994). By identifying architecture with its modern merits, this thesis focuses on describing the current dynamics of informational revolutions as reflected on the scale of production and the cognitive, theoretical agenda. The digital culture and paradigm in architecture, as a modern discipline, have changed the roles and tasks of the architect in the profession, and challenged the discourse on the architectural subject, as well as the means of production and design. This inquiry also evokes the primary question regarding the conjunctive and disjunctive grounds between the role of the architect and the innovative progress of architectural technology. The dynamics outside of the closed culture of architecture, concerning industry, production, science, and technology, should also be primarily introduced to those relations. Accordingly, this thesis aims to provide an understanding of how the recent advancements in technology, production, and informational studies can affect architecture, its practice, theory, and its agents.

This inquiry was highlighted by Objectile, which can be described as the technological object designed and produced by advanced informational technologies; its counterpart, Subjectile, can be described as the interface or outcome of the performative and creative act of the subject. Possibilities and obstacles between Subjectile and Objectile were also questioned to theorize whether there is a subjective behavior identified with a connected and correlated artificial agency. This question enables the assessment of whether the creative or intuitive act or particular behavior of the individual can still emerge in the dynamics of the built environment when they are also monitored through the production relations. Such activity, respectively, is expected to define what Subjectile actually is in Industry 4.0. Accordingly, Subjectile will be freed from the misunderstanding of 'the error' of the craftsmanship when it is considered in the built environment with Objectile, as the technological object that would relentlessly show any error other than the given information. Hence, Subjectile can be understood as an exact creative contribution of an individual in production, yet it is expected to be updated in line with changing technology and even scientific basis. In this regard, the distinguished attributes of the evolutionary behavior of the subject to overcome the limits of the Objectile and the predetermined Subjectile are questioned.

The motivation behind this thesis includes an inquiry that is based on how the relevant discussions and studies on cognitive sciences, information technologies, such as AI, and production technologies influence architecture. Briefly, the motivations bind the aims and research questions, drive the inquiries throughout the proposed methodologies and urge a survey of the related dynamics, as is also outside the modern culture of architecture concerning:

- The search for a common mindset between the subject and artificial agents to read the collective agency of architecture in knowledge generation as intelligence;
- The peculiarities of architects, such as creativity, and their collective form in interaction with architectural technology, so as to redescribe Subjectile in the dynamics of the built environment and intelligent spaces;
- Analyzing Objectile and the rise of new technologies;
- Models and relations for humanized technology in human-computer interactions related to the creative cognitive activities in architectural production and design;
- Defining the roles of intelligent spaces for new Subjectile-Objectile relations with artificial intelligence, Big Data, and IoT technologies, and other means of crowdsourcing in architectural interfaces, spaces, and developments;

- Understanding the ever-achieved complexity of different reference systems of production, design, and architecture regarding spatiotemporal experiences to evaluate the digital paradigm in architecture and the built environment;
- Revealing the togetherness and discreteness of the evolutionary transformations of the built environment and the digital paradigm in architecture;
- The new thresholds of the subject from the question of Subjectile in human-artificial correlation and its collective formations;
- Shared mindsets between the subject and the artificial;
- Human-nature-artificial interactions and (informational and relational) topologies to question the potential, difficulties, and challenges of organizational considerations as creative evolution(s) in architecture;

1.3. Scope of the Thesis

The investigation of human-computer interaction with repercussions on and from the built environment will attempt to focus, together with the role of intelligent spaces, on understanding the new relations between Subjectile and Objectile. By analyzing the gap within the existing literature in the digital paradigm concerning the collective role of modern environments, such as university spaces, the research will attempt to understand Subjectile-Objectile and environment relations. The research investigates the particular roles of intelligent spaces accordingly by exploring cases from the learning environments of scientific and academic intuitions, such as smart campuses.

In line with the research aims, this thesis investigates the strong repercussions of cognitive and natural sciences, as well as behavioral, social, and human sciences, aside from industry and technology-related economics, on architecture, design, and urban environments. Hence, this wide-ranging scope of interdisciplinary investigations can be extended to grasp the production and theory-based correlations, paradigms, and methodologies. This broad scope refers to the modalities between human, artificial, and environmental agencies as topologies. It reveals the challenges of related practice and theory of the organizational, cognitive, informational, and educational/epistemological aspects of architecture that are to be investigated through technology in learning/intelligent environments. This inquiry also explores the rising impact of smart systems/grids and smart cities, robotics in construction, and networks of human-computer interactions/interfaces together with innovative means of practicing, theoretical modeling, crowdsourcing, and data processing methods.

At this point, it is also crucial to note the corresponding experiences of architecture departing from modernity to post-modernity, in the emergence of Deconstructivism, towards the new paradigm by the digital turn(s) in architecture. This investigation corresponds to the evolutionary progress of the industrial revolution[5] beyond being a breaking point of production and knowledge in time that also transforms the relatively closed culture of architecture. The latest informational revolution of artificial intelligence with reciprocal networks of Industry 4.0 and 5.0 [6] revealed the corresponding advances in informational technologies. In this scope, the role of information requires understanding architecture through the dynamics of novel means of computation and the future of state-of-the-art technologies (Erişen, 2018a).

It is crucial then to broaden the research horizon towards novel technologies: the capacities of production, and speculative executions in their potentials and limits, as well as their effects on the alteration of architectural design and production. The direct correspondence of computation with the material and the environment by nanoscale production has revealed itself in 'atomically precise manufacturing' (Drexler, 2013). The rising studies into 4D printing in architecture, besides molecular computing and synthetic biology, have added to these new potentials for intelligent spaces and in the foundation of smart campuses with experimentational laboratories and new technologies. Moreover, the digital twins with augmented reality, as well as the emergence of neuromorphic computer chips[7] and their possible relations with humans

[5] The informational revolution of the data-driven processes of decision mechanisms and the end-product through atomically precise manufacturing describe the breaking point of the dynamics of professional practice and theory. This thesis scrutinizes the term revolution closely in its production-based and social relations in an evolutionary progress of open systems as the environment and life itself. Since the information age emerged within a close relationship between science and technology, the revolution in industries has emerged as a creative breaking point of that evolution.

[6] Among the other industrial/technological revolutions, Industry 4.0 indicated the "introduction of connected devices, data analytics and artificial intelligence technologies to automate processes further" (Özkezer, 2018) creating the networks of communication and production besides the correlation with 'atomically precise manufacturing' capacities. Industry 5.0 defining the human-computer interaction at the very complex level, on the other hand, can be implied with the delivery of neuromorphic chips that Intel introduces, which become capable of much more complex performative tasks. "Industry 5.0 is focused on the cooperation between man and machine, as human intelligence works in harmony with cognitive computing." (Özkezer, 2018). See also (Rada, 2019)

[7] See also (Davies, et.al, 2018).

and environmental interactions, have indicated the effects of state-of-the-art technologies of human-computer interactions towards Industry 5.0 (Özkezer, 2018; Rada, 2019). In addition to neuromorphic computing chips, other state-of-the-art quantum processors, such as nanophotonic or molecular computing, have increased the efficiency of information processing, communication, and computation (Erişen, 2018a), and indeed they imply novel industrial transformations.

These developing technologies are also evaluated in terms of their limits, potential, and necessity in the design of the spatiotemporalities of smart environments and effects on abstract interactions and decision-making models in architecture. Therefore, further explorations of abstract models and modalities of human-computer interfaces, technology transfer models, multi-agent systems, and many-body systems for the creative organizational possibilities of the agencies of architecture are conducted in the design and development of intelligent spaces and learning environments, such as smart campuses. Thus, the thesis also investigates the roles of evolutionary and advanced metaheuristics, and informational processing algorithms with regard to the new generation, state-of-the-art technologies, and the future of AI, Big Data, and the IoT for architecture.

1.4. Hypotheses and the Premises of the Thesis

The thesis claims that creative evolution in architecture can be described through new human-technology-environment interactions to be read through Subjectile-Objectile relations and evolutionary transformation of the built environment towards intelligent spaces. The rise of technology in architecture defines novel theoretical and organizational formations regarding the agency of architecture. The rising and new generation technologies require novel research agendas and critical approaches with collective organizational formations of subjects and artificial agents. The thesis claims that new state-of-the-art technologies and agent-to-agent relations between humans and technologies in design and production urge us to study the redefinition of Subjectile according to the evolution of the technological object, Objectile, under the rising impact of intelligent spaces. This needs to be studied with new collective and conceptual inquiries by subject-architect and technology relations regarding the potentials of neuromorphic computing chips, 4D printing, IoT-based design, as well as other new generation computers for the future of smart built environments, and new organizational forms among creative agents within architecture.

It is hypothesized that creative evolution in architecture can only be understood through new Subjectile-Objectile relations by considering the evolutionary transformation of the built environment, with collective forms and technology in architecture influenced by industrial revolutions. Further technological developments derived from architectural endeavor, such as intelligent spaces, can be the testbeds for those advancements to guide unified and critical collective organizations.

The potential of creative and intellectual thought makes sense, in that regard, once they have been found to be consolidated with the phenomenal facts and experiences. Accordingly, architecture occupies novel production relations under the generic dynamics of theoretical concepts and human-computer-environment togetherness. This research proposes the peculiar potential of the subject with the collaborative networks of innovative architectural technologies and the built environment with the dynamics of creativity. The new opportunities of Industry 5.0 imply the potential for progressive evolution with technological investigations in the environment. This possibility necessitates a critical stance to consider these developments with the dynamics of the knowledge and production of the built environment. Moreover, such considerations offer possible theoretical opportunities and methods of constructing logical and discursive practices to think about the associated environmental challenges, and to plan the future of natural and built environments, such as smart campuses.

To conclude, this inquiry necessitates looking for the correlations and fine distinctions between the Subjectile and Objectile, rather than solely defining the dynamics with regard to perennial industrial revolutions. Hence, the topological modalities between human-nature-artificial define the upper and lower boundaries of knowledge landscapes and new organizational formations, and correspond to the higher dimensional complexities of the evolutionary agenda of architecture. Overall, this research can be seen as an endeavor to theorize:

- a new research agenda of architecture through 'the multi-existing dynamics of creative evolution',
- a critical inquiry into the relations of creativity of the subject and architectural technology, and
- the reorganization of (and with) the built environment regarding the creative subject of architecture and its critical collective formations by technology and theory.

1.5. Contributions and Limitations of the Thesis in the Literature

This thesis offers a critical reading of evolutionary architecture with abstract models of thinking, organization, and theoretical/epistemological evaluations. The comprehensive examination of the existing and evolving circumstances of architecture by evaluating the key term of '*Creative Evolution*' can be seen as a peculiar attempt in architectural literature. Respectively, this work attempts to describe how architecture has responded to the evolutionary changes of the last century regarding its distinguished paradigms. The related research fields in question extend from cognitive, computational, behavioral studies to the cultural and organizational correspondence of architecture in relation to industry, production, science, and technology in evolutionary trajectories. This thesis can hence be seen as a theoretical endeavor including many accompanying examples, abstract models of practice and decision-making, research fields, as well as ongoing spatiotemporal experiences.

With the initial inquiries of Le Corbusier (2006) and Sigfried Giedion (2008) with space-time perceptions about the industrial impacts on design culture, the evolution of modern architecture has been analyzed and categorized by the related research of Frampton (1992; 2006) and Jencks (2006). The rise of the digital media in design and production, together with the inspiring studies on nature, have resulted in the studies of Lynn (1993; 1999) and Frazer (1995) as milestones of a novel paradigm, and volatilized the new research agendas within subsequent industrial revolutions. Subsequent years have also seen other significant examples, such as Schumacher's (2011a; 2011b) parameter-based algorithmic approaches inspired by the self-replicating and evolutionary mechanisms in life.

Being theoretical bases of the transformation in the culture of architecture, the peculiar endeavors of Picon (2010), Carpo (2013b; 2017), and Deamer (2015a) are among the most impressive references, with their attempts to outline the new dynamics of the profession. It is crucial to note the potential and problems of professionalization, including internalities and the dynamics of individual and collective beings within this work. Therefore, it is important to clarify here that the architect cannot be seen as an individual agent in the rising expectations of the workflow and teamwork, but rather as a networked agent. The attempt will be made to define this identification through the theme of intelligence, with strong influences of actor-network theory (Latour, 2005), and also by referring to Herbert Marcuse's seminal study on performance principle (Marcuse, 1998).

Nevertheless, as the dynamics and problems of professionalization and the role of the architect are deeply explored by Deamer (2010a; 2010b; 2015a)[8], Bernstein (2010a; 2010b), Tombesi (2010), and Taylor (2010), the research refrains from adopting further similar approaches, which of course represents a limitation of this research. The study instead focuses on the novel grounds of the subject-technology relations, regarding them as new Subjectile-Objectile relations in the relative dynamics of technological innovation and science explored to their fullest extent. This approach will further enable us to focus more on the evolutionary dynamics in human-technology-environment relations (Peters & Peters, 2018) that have creative leaps with new and old struggles coming from the precedent periods, just to be read by the concept of creative evolution. Moreover, the inquiries into new technological developments for human-computer interactions, modalities via new Objectile-Subjectile relations, and on the innovative developments of learning environments distinguish this research from the early studies of Carpo, Deamer, and Picon, as well as Peters & Peters.

[8] Deamer (2015a) also noted the role of creativity and task-intense activities to be understood through the pleasure principle. Deamer's (2015a; 2015b) idea dwelled on the greater emphasis and greater interest on the playful enjoyment of task. Deamer's approach, in that sense, can also be evaluated as a contribution regarding Freud's pleasure principle and Marcuse's performance principle together. In this study, it was to understand the changing dynamics of human-artificial interaction and the evolutionary transformation of the urban milieu together with the environmental challenges, as well as to imply the new thresholds for the architects that become subjected to the change in technology and top-down investment decisions of capitalism, and yet to break the boundaries of the crisis-prone repetitive and cyclical loop of production-investment dynamics.

The research also claims to have found knowledge bases and their corresponding informational modalities that can be followed through each corresponding chapter and section with regard to the themes of evolution and their corresponding space-time conceptions. This work also concerns the informational grounds of common interfaces between the human, artificial (computation), and nature (environment), such that it also considers this epistemological endeavor as a challenge of conscious decision-making. Respectively, by integrating the logical executions in the practice and logic of spatiotemporalities, as Alexander (1977) did, this study becomes more distinguished from the above-mentioned and well-known theoretical studies. Similar to the seminal approaches of Negroponte (1970), Akın (1986; 2006), and Mitchell (1994) about the initial transformation of architectural design and its logic with artificial intelligence, this research also attempts to explore the common logic between human-computer interactions. Accordingly, this study attempts to find new grounds of discussion between Objectile and Subjectile (Cache, 1995) through the relation between the subject, technology, and the environment.

The larger-scale transformations of the digital influence in architecture and urban environments are also accordingly studied. It is possible to read the dynamics of the information age and architectural built environments by grasping the socioeconomic dynamics and organization of space. Thus, the literature covered in this thesis includes Mitchell's vision of the deep infrastructural revolution of the cities by ubiquitous and quantum computing, learned from his book *Me++* (2003b). Similarly, Batty's (2011) mathematical considerations in the control of flowing relations of the city, as well as Picon's (2015) seminal consideration towards Smart Cities, regarding a spatialized intelligence, are included in this investigation. This research, respectively, corresponds to a virtual transformation of the informational interfaces by defining the new domain of 'urban informatics' (Foth, 2009). The substantial changes of the elements of the built environment are further defined through the idea of 'electronic twins' (Mitchell, 2003b), or the Digital Twins (Batty, 2018), corresponding to the entanglement, or at least strong correlations, between the physical entities and virtual informational bases.

The related transformations in the tectonic aspects of the built environment, respectively, gave birth to the rising paradigm of Interactive Architecture and

Embedded Computation that were seminally explored by Fox and Kemp (2009). Those endeavors have increased the focus on instrumentalizing the tectonic elements of architecture via the relative concepts of responsive and adaptive architecture (Rodolphe, Marcopoulos, & Moukheiber, 2012). Accordingly, Lehman's (2017) hypothetical discursive constructions, offering new spatiotemporal possibilities of the learning environment with regard to changing technology, reveal similar approaches to understand the networked individual agency with technological and artificial elements, as well as with the environment itself. Thus, the specific declaration of this thesis is to find models, methods, and theoretical grounds for human-nature-artificial topologies through correlations and disjunctions between Subjectile and Objectile by subject-environment-technology relations, specifically investigated through intelligent spaces.

The most recent spectacular examples of the perpetual transformation of architecture with technology and science have shown the most robust evidence of '*Robotic Building*', even in constructing the built environment with embedded intelligence and fabricating agencies (Claypool, Garcia, Retsin, Soler, 2019). The evolution from the digital turns of architecture to the paradigm of robotics in automation was revealed by the many seminal essays of Carpo, Yablonina and Menges (2015), Lynn (2012), and Picon (2019), amongst others. Thus, the fledgling paradigmatic interpretations of robotic agencies and human-artificial interactions towards Industry 5.0 have been fully determined with their collective complexities of the new paradigmatic resolutions by the concept of 'intelligence'.

The rising impacts of smart spaces and urban computing on the built environment also have paramount importance, with substantial grounds referring to this reproduction in architecture. It is crucial here to introduce the emerging paradigmatic bifurcations, even concerning the role of robotics, human-computer interaction, automation in construction, and the rising impact in smart house systems. The architect Gilles Retsin's seminal article, '*The Discrete Architecture in the Age of Automation*' (Retsin, 2019), questioned the creative role of specialized artificial agencies, not only in informational processing but also with regard to the modalities of things that exist and emerge as entities of the larger constructed assemblies. Apparently, this modality even exists in the case of the lavish robotic construction of brick masonry (Yuan, 2016). On the other hand, string-like construction agencies, like 4D printing, as open and closed strings, continuous mortar of additive manufacturing for the togetherness of assemblies, aside from other performative aspects and application of forces, indicate the continuous modalities in their complexity (Leach, 2019). The designed spatiotemporalities inside and outside under the seminal ideas of non-discrete architectures and performativity, so to speak, reveal another type of continuous modality, while it does not hinder the design of discrete architectures (Hensel, 2013).

By reading those arguments with 'creative evolution', including the agencies of subject, object, and environment, this research claims to reveal the capacities of subjectivity and its thresholds for creative organizations with technology and the environment. It is a transformation that also implies the novel evolutionary dynamics towards the interpolation of agencies by the unified understanding for critical consciousness of different subjects busy with technological apparatuses and environments.

In short, 'Creative Evolution' is used as the governing idea between human-computer interactions regarding the role of creativity, and in describing the evolutionary relations between architects, artificial agents, nature, and the built environment towards intelligent spaces. The theme also helps to understand the impacts and processes of earlier industrial revolutions. Since similar research in the architectural literature do not analogously refer to this concept, it is seen as significant to include theories from 'creative evolution' (Bergson, 1998), which also helps to emphasize the modern theoretical bases and conceptualizations for the evolutionary perspectives.

In this regard, how architecture, its practice, and theory with its collective groups of architects evolve with these evolutionary multiplicities is evaluated by grasping the changes in technology, industry, and the built environment. This conception ascribes to the social and spatial role of intelligence through human-technology-environment relations, and can be analyzed through intelligent environments and university spaces that are not significantly surveyed in the associated literature. In this regard, it is possible to grasp how the internal changes in these modern built environments can be read as spatiotemporal reflections of creative subjects' collective intelligence in campus environments to describe an evolutionary progress defined by industrial dynamics under the theme of creative evolution. Evaluating the new Subjectile-Objectile relations with regard to the selected cases and research for the evolutionary transformation of the built environment towards intelligent spaces, in learning environments of scientific and academic institutions and smart campuses, is also a particular attempt in the architectural literature to give examples of creative evolution in architecture.

1.6. Methodology of the Thesis

The research attempts to define the creative evolution in architecture, investigating new Subjectile-Objectile and environment relations, in particular by looking at the evolutionary transformation of the built environment, architecture, and technology towards intelligent spaces and learning environments of smart campuses. The form of intelligence described in the book by Bergson (1998, pp. 186-272) enables one to understand the (re)conciliation between different agents, nature, and the environment, both materially and cognitively. Thus, the methodology of the thesis applies (1) the content analyses of the related works and research, selected and surveyed through key concepts within the theoretical framework; and (2) the spatiotemporal analyses of the related cases from the built environment in each chapter to understand new human-technology-environment relations with their spatiotemporal, cognitive, and substantial material aspects.

Thus, the thesis focuses on new Subjectile-Objectile relations under the recent influences of technology, intelligent spaces, learning environments, and smart campuses within the evolving built environment. The methodology investigates the missing role of university environments in understanding the new relations between Subjectile-Objectile in the evolutionary built environment; and aims to come up with a research effort having particular outcomes relating to smart campuses in the development of intelligent environments.

In brief, the methodology of the thesis applies both spatiotemporal analyses and the content analyses of the related research that are surveyed according to the theoretical framework, developed by research questions and the background research on the evolutionary change of the built environment and technology in architecture. The study starts to define the primary research question on the evolving human-technology relationships in architecture via new peer-to-peer Subjectile-Objectile relations. Within the defined theoretical framework for a search on the common mindset between human and technology relations, the research applies content analyses of significant research on the selected key themes of performance, affect, and intelligence (Bergson, 1998; 2002; Marcuse, 1998; Picard, 2000; Ballard, 2015). The study also looks for particular examples of spatiotemporal analyses regarding the role of intelligent spaces for each concept. Thus, the thesis applies spatiotemporal analyses and content analyses to describe new Subjectile-Objectile and environment relations.

The thesis also asserts that new human-computer interactions cannot be understood without looking at significant works describing the evolutionary transformation of the built environment and the emergence of the technological paradigm under the strong influences of Industrial Revolutions. The thesis thus includes a survey on the historical evolution of the built environment and technology relations, discussing the modernist turn and digital paradigm in architecture in terms of discrete and evolutionary trajectories. The research applies the content analyses on the seminal discussions of work such as that by Giedion (2008), Frampton (2007), Jencks (2000), and Koolhaas (1994). By doing so, the research aims to understand the evolutionary transformation of the modern culture and the built environment together with related spatiotemporal examples, particularly looking at the influences from the Dutch culture and CIAM gatherings. Similarly, the digital paradigm in architecture is tried to be understood by regarding the scientific grounds with industrial influences, and seminal theories of Lynn (1993; 1999), Cache (1995), and Frazer (1995), and other significant works and articles that have been identified for the initiation of the digital paradigm (Picon, 2012). This generates a systematic analysis of the evolving technology and the built environment in architecture. With a critical inquiry into the role of intelligent spaces and university environments, the thesis maps the evolutionary transformation of the built environment and the technological paradigm together by applying both spatiotemporal and content analyses. The research finds a gap in that the university environments are not significantly discussed in the digital paradigm of this evolution.

This gap is found to be significant in terms of evaluating the collective role of university environments towards the transformation of intelligent spaces further in understanding the human-technology-environment relations as topological complexities.

Then, the fourth chapter applies the content and spatiotemporal analyses on examples and cases that are influenced in the period of Industry 4.0 towards 5.0 to understand new human-technology-environment relations. The chapter aims to found theoretical constellations among these pragmatic examples as a method of intelligence that Hoorn describes (Hoorn, 2014), as well as research methods and abstract models to be applied/read, once again as a method for creativity (Hoorn, 2014), through intelligent spaces of smart campuses in the fifth chapter. Thus, the fifth chapter investigates the selected cases of intelligent spaces and learning environments of smart campuses by content and spatiotemporal analyses of the corresponding research in understanding the new Subjectile-Objectile relations in close relation to the environment and intelligent spaces.

Briefly, by applying both the content and spatiotemporal analyses to the selected works, research, and cases in the defined theoretical framework through selected key concepts such as intelligence, this thesis first introduces empirically intense studies on the research question about the rising complexities of human-computer correlations. The inquiry into human, technology, and environment relations is further augmented with historical background research, focusing on the non-linear evolutionary dynamics of architecture from modern times towards the digital paradigm of architecture in relation to production and technology, including the transformation of the built environment. For the conceptual analyses and creative syntheses, the study aims to find a theoretical approach to reading the emerging themes and arguments through linear modalities and modulations (classifications). This approach complies with the aim to have theoretical argumentations and conceptualizations based on the topics included in the discussion by critical reading on human-computer interactions and collective organizations in the built environment. The research finally gives examples of analyzing new human-technology-environment relations that are grasped through the rising impact of intelligent spaces and smart campuses.

In each chapter, the thesis aims to understand how intelligent spaces and evolving smart built environments can be beneficial in understanding the new Subjectile-Objectile relations, where the thesis particularly investigates the role of universities and smart campuses in describing the creative evolution in architecture. In this regard, with the aim of the methodology, it is believed that the research can be beneficial to decision-makers and authorities in the research and development of university environments, intelligent spaces, and smart campuses. The research could also be beneficial to the designers and researchers who research evolutionary paradigms and theories of architecture, as well as architects, planners, engineers, and scientists who study intelligent spaces, learning environments, smart campuses, and new human-computer interaction relations. With its particular content, the research could also gain the attention of audience and researchers from administrative, cognitive, and behavioral sciences regarding the effects of new generation technologies in architectural research and practice.

1.7. Structure and the Content of the Thesis

The structure of the thesis can be briefly summarized as follows: The second chapter puts forth the primary research questions and the theoretical framework in the evaluation of new human-technology relations in architecture by claiming necessary research further on the evolving built environment, industry, and technology relations. The third chapter presents background research on the evolutionary history of their transformations, and finds the gap in the corresponding literature to read new human-technology relations with the evolving built environment. The aim of the fourth chapter is to derive theoretical conceptions and abstract models by clustering the significant selected examples and cases under the impact of Industry 4.0. The fourth chapter thus studies key concepts, spatiotemporal cases, and methods of how human-technology-environment relations can be read and classified under the containing concept of creative evolution in architecture. In the evolutionary transformation of the built environment, the fifth chapter focuses on the particular cases of intelligent spaces in smart campuses to understand new Subjectile-Objectile relations in the built environment. The chapter thus gives examples of creative evolution in architecture based on new subject-technology-environment relations, indicating the outcomes and potentials of the research accordingly.

The second chapter builds up the discussion on the correlations and distinctions between human and artificial agencies in design and manufacturing. It also looks for the internal dynamics of the evolutionary profession of architecture with its agencies that coexist with technological and industrial/scientific evolution in practice and thought. This investigation attempts to argue that there is a necessary transformation in the mindsets of design and thinking. Respectively, the intention is to discover the common ground between humanity's nature and the informational evolution of technology based on some critical concepts such as performance and intelligence, and to discover the genuine potentials of the creative subject by other domains such as affect and consciousness. Therefore, the second chapter introduces the key elements of theoretical arguments to conceptualize a mindset, understanding the architectural agency's predicaments[9] in the information age under the theme of evolution. By reading Bergson's '*Creative Evolution*' and his key writings (1998; 2002), the theme of intelligence stands to understand the tangible and cognitive form of 'intelligence' through the relations of subject-architect and technology in the natural and built environment.

In this regard, the emerging common ground between the human and artificial agents is to be read through performance, affect, and intelligence for, and with, the theme of creativity. The technological revolution of digital twins and new technologies, even such as neuromorphic computing, imply the evolutionary transformation of subject, technology, and environment relations. Accordingly, this implies the transformation of the mindset of the creative subject of architecture when defining the complex topology between the subject, natural, and artificial environments, and the agency of technology. This proposition corresponds to the potential of possible interactive practices between Subjectile and Objectile of Industry 5.0 and their spatiotemporal reflections on the built environment via intelligent spaces.

[9] Architectural agency, here, ought not to be seen as a mere subject of labor, but as the creative force and an evolutionary being in the emergence of knowledge from the experience and organization of space-time constructions yet to be subjected to the dynamics of its own age; and once again affecting those dynamics.

The third chapter can be seen as an overarching and comprehensive survey of the historical background of evolutionary trajectories of architectural movements, as reflected in the transformation of the built environment parallel to the evolution of the industry and technology. The chapter refers to significant figures in architecture's narratives such as Giedion, Frampton, Jencks, Lynn, Carpo, Picon, and the new avant-garde practice(r)s and writers. In this regard, the third chapter explores the evolutionary transformation of architecture with its existing modern built environment, heavily affected by the industrial revolutions, CIAM gatherings, and significant paradigm shifts by political, scientific, and social incidences. Accordingly, the premise of the third chapter is to understand how the early modern periods of industrial revolutions evolved into the current formal mode of architectural practice and theory. The chapter further questions how the digital paradigm has emerged from a completely discrete evolutionary trajectory of science and technology corresponding to the non-linear references of the built environment we live in and the technological environments we utilize[10]. The chapter also considers the evolution from modern avant-garde movements with the changing paradigms by industrial revolutions at the outset of the interpretation of creativity for new subject-technology-environment relations.

This part of the study starts with simpler oppositions in the modern culture of architecture and the built environment, as closely related to the first industrial revolution. The changes in the different modern environments by a series of (re)constructions have created our main milieu of everyday life. As in Haussmann's destruction and reconstruction of Paris, or in the rise of urbanization of New York City or Chicago by industrialization, as based on a grid scheme, the way we live in cities is still devised by the spatial production of the precedent industrial revolutions. Accordingly, the changes from modern and post-modern culture towards Deconstructivism are first scrutinized via the accompanying references, such as

[10] Architecture as a profession from the early modern periods has evolved into a complex formation of theories and practices. The built environment that we live in, relatively, corresponds to the influences of different periods of industrial & informational revolutions. Accordingly, the knowledge field in which we searched for the practice and theory of architecture constitutes the influence of those multiplicities and the recent technological advancements. Those advancements increase the possible fluxes of different scientific, social, cultural referential bases -merged into each other. By describing the chaotic form of confluences, the third chapter first has a critical gaze to the corresponding condition of architecture and its built environment in the information age.

Giedion (2008), Frampton (2007), Jencks (2000), Tschumi (1994a; 1994b; 1994c), and Koolhaas (1994a; 1994b). The evolutionary trajectory in the modern built environment is evaluated with the faint traces of the influences of Dutch culture, consistent in itself, that will appear once again in discussing TU Delft campuses' spatiotemporal cases. The research then shifts towards the new technological languages of design and theory pioneered by Lynn (1993; 1999), Cache (1995), Frazer (1995), Schumacher (2011), and Menges (2011). The consideration of the togetherness of these two distinct domains of research, even in the academia of architecture, describes the multiplicity of different reference systems (and actors) in the profession of architecture.

Therefore, the chapter follows the emergence of those multiplicities as different reference systems of practice and theory evolving from their originating roots with simpler oppositions to be defined within the creative evolution in architecture. The chapter regards two distinct turns that have evolved with industrial and technological transformation: the first is the modernist turn; the second is the digital paradigm in architecture (Picon, 2010; Carpo, 2013b). The deliberate analyses of the existing literature show that the transformation of the modern university environments in the digital turn has been missed out. In this regard, the study of university campuses is seen as crucial, with further attention to evaluate the evolutionary environments and even organization of the academic and creative subjects. This finding also offers creative studies and conceptual models for new research outcomes to be testified through the spatiotemporal and organizational potentials of universities.

The fourth chapter, then, contains analytical research on how theoretical modulations and abstract models can be derived from the existing examples, research, and cases under the strong influence of Industry 4.0 in order to better understand the evolving human-technology-environment relations. The outcomes of the fourth chapter imply certain methods and cases to be studied in the following (fifth) chapter with the precedent concerns of the third. In this regard, notable examples, mostly related to the epoch of Industry 4.0, are researched to determine the relation of the subject to the problemata of new transformations of external references of technology, production, and the built environment in a more abstract manner. By offering abstract concepts as an analytical method to (re)classify the complex modalities of the creative evolution, this chapter aims to develop conceptual bases to determine further case studies on the future of university environments with intelligent spaces and new Subjectile-Objectile relations. The fourth chapter, indeed, attempts to develop theoretical models for the creative subject-technology-environment togetherness that is not yet well reflected in the existing circumstances of architecture.

The fourth chapter sheds light on the empirical aspects discussed in the preceding chapters by resurveying the implied relations through conceptual argumentations of space-time to classify the complexity of paradigms in architecture[11]. Accordingly, the analyses include the key terms of duration, motion (Bergson, 1998, pp. 1-11; 298-314), and bioinformatics and swarm intelligence, Objectile and Subjectile (Cache, 1995), and territorialization and deterritorialization with their common corresponding philosophical backgrounds (Deleuze & Guattari, 1983; 1987; 2000; 2005; Guattari, 2013). Relative to the search on the evolution and information through theoretical conceptions[12], the empirical aspects can be highly engaged with the co-planar growth of the technological means of our everyday lives. By shifting the dimensional experience of identities and societies, informatics enables us to think about the abstraction of possible experiences. However, it still forces us to remain within the bounds of materialistic dimensions of actual sensual space. Accordingly, further analysis is conducted with regard to the interactions between the nature of things and the psychological and cognitive aspects of the 'organizational agency' of architecture by the critical concepts of 'Objectile' and 'Subjectile' in the rise of information technologies[13].

With these theoretical concerns, the fourth chapter aims to classify significant

[11] From the sensual space-time to social construction of spatiotemporal experiences (Harvey, 1996), the classical arguments on space-time (Akhundov, 1986) deal with the empirical issues observed in the measurable (divisibility of) time in space. The rationality of that experience has certain borders that are limited by the empirical experiments and sensuality of subjectivity as a language construct in creative evolution.

[12] The theoretical background of the scientific research, in this study, prospects the theme of evolution and coeval growth of the information theory and technologies that are coherent with the science of statistics of entropy and statistical mechanics. The theoretical axioms and rules that would be introduced can be seen as the epitome of empirical evidence of sensual experience in space-time as in the rules of thermodynamics, the laws of motion, or in the biological and ecological behavior of creatures and agents and their geometrical intuitions.

[13] The chapter, hence, starts with discussing the scientific endeavors concomitant with the technological possibilities, which result in the emergence of the multiplicity of logical systems offering various potentials of artificial intelligence. That starts a discussion of 'information' as an interface between the object (phenomenological) and the subject (intellectual), between the actual and virtual. The aim of this work, accordingly, undertakes an overview of the trajectories of subject-object togetherness and their distinctions by the closer inspection on information.

examples through selected key themes under the containing concept of creative evolution in architecture. Thus, the fourth chapter is divided into three sub-chapters with regard to the selected key themes of duration, motion, and bioinformatics and swarm intelligence in order to understand different conceptual aspects in human-technology-environment relations in creative evolution. According to the first sub-chapter, the production-based development of informational technology of Industry 4.0 first reminds us of the significance of the analyses to the properties and feature-based identities of things[14], representing their emergence in time. The duration of things that appear with their feature-based properties also reveal the scientific agenda behind the precedent industrial revolutions, as in the case of the inquiry into thermodynamics at the outset of steam technology. With the rise of the knowledge domain in the scientific inquiries of motion, as studied in the second sub-chapter, further growth of new technologies and advancements from steam technology to the mechanical, electrical, and informational revolutions[15] became possible. Accordingly, the rise of the flow of things in time, as it becomes a part of production and communication, gives way to the current potential of technological advancements in Industry 4.0 and, indeed, even for Industry 5.0. The aim is to narrate them together in this study in relation to the informational flow in the production-based properties of things that are caught with their motion in space-time. Moreover, measuring things with their actual states and actions is questioned through the novel fields of informational studies such as swarm intelligence or bioinformatics as a distinct sub-chapter. The third sub-chapter on bioinformatics and swarm intelligence in architecture, relatively, has novel excursions on the information-related measurements and creative models of sensual experience in space-time, and their spatiotemporal reflections in design, construction, decision making, and crowdsourcing in the new human-technology-environment relations.

The fifth chapter then analyzes particular cases of the intelligent spaces and learning environments of scientific and academic institutions and the smart campuses of research universities regarding the previous concerns of the thesis on the collective

[14] This can be exemplified in the growth of search in nano-sciences as well. See also to Zak's (2011) studies on quantum computation and intelligence in the exploration of the features of natural beings.

[15] Scientific progress can give clues about the theoretical models such as Boltzmann mechanics, Brownian motion, the equations of entropy, and then the electromagnetic interactions of particles.

role of universities in the spatiotemporality of the evolving human-technology-environment relations. The chapter enables us to follow how previously studied key concepts, research, examples, and methods are applied through the particular cases of intelligent spaces and smart campuses. The research also enables to determine how new Subjectile-Objectile relations can be read through intelligent spaces, learning environments, and smart campuses in the creative evolution in architecture. The rising technological and scientific investigation in research universities with existing and robust studies for smart campuses are regarded together with the spatiotemporal cases of intelligent spaces and practices therein.

Examples from TU Delft campuses with corresponding researchers and literature, as well as selected examples from MIT and Harvard University, are presented to be evaluated with regard to the expectations of the thesis on the studied crowdsourcing and decision-making models. As studied previously, new generation technologies, data collection and processing methods, advancements in design and construction techniques, remote sensorial networks, and new interfaces on new human-technology-environment relations are analyzed through these particular cases. Thus, the role and impact of IoT applications, simulations via artificial intelligence models, as well as the new generation computers, new manufacturing and design technologies applied in these cases are inspected through spatiotemporal reflections, and further through the content analyses of the corresponding research, reports, and information.

Respectively, the study also has relevant research inquiries on the local conditions of research universities and technoparks in Turkey, such as ODTÜ Teknokent and Bilkent CYBERPARK. These selected cases are to be inspected through similar expectations of intelligent spaces, learning environments, and smart campuses to develop new Objectile-Subjectile relations. The chapter also indicates the research outcomes and particular benefiters of the research to those who may be interested in the cases studied. In conclusion, the research gives examples of new human-technology-environment relations in describing creative evolution in architecture as a containing concept of the thesis.

CHAPTER 2

FORM OF RELATIONS BETWEEN THE ARCHITECTURAL SUBJECT AND TECHNOLOGY

2.1. Introduction

The evolution from the non-linear planar production of Subjectile towards the computer-based non-standard production of Objectile (Cache, 1995) implies the new role of the architect. New generation technologies implying the initiation of Industry 5.0 (Rada, 2019; Özkezer, 2018) like neuromorphic chips[16] or 4D printing, and digital twins, in that regard necessitate the redefinition of the term 'Subjectile' as creatively produced interfaces with technological objects by subjective contributions. Thus, Bernard Cache's seminal argumentation on Subjectile and Objectile (1995) in the dynamics of advanced human-computer interaction needs to be decoded to put the role of the architect and his/her creative act into new practice with regard to the evolution of architectural technologies.

The thesis investigates other possibilities of Subjectile in the creative act of subject by conscious decision making, design, and production beyond the existing discourses on artisanship in production, as Cache (1995), Frampton (2010), or Carpo (2017) have already argued. Respectively, creativity is put into question in cognitive aspects of conscious decision making in close correlation with technology by the performative, affective, and intelligent act of the creative subject.

The informational capacities have changed the modes of design thinking by merging the three different concepts of form, function, and even beauty into singular but distinct forms of performative actions. It can be claimed that under this transformation, production and manufacturing techniques have evolved significantly. The emergence

[16] Intel has recently distributed Pohoiki Beach neuromorphic computing chips, which represent the 5th generation neuro-computation after LOIHI, including 130.000 neurons that first appeared in November 2017 (Lin et al., 2018; Intel, 2019).

of artificial agents as possible future actors or novel concepts of 'actor-network theory' (Latour, 2005), together with the socio-cultural influences, reveal the striking progress towards Industry 5.0. By analyzing the critical position of the individual and the collective labor in the new dynamics, the study investigates the significance of the architect with regard to the collective merits of performance, what Herbert Marcuse theorizes by performance principle (Marcuse, 1998). This discussion is followed by pondering the intelligent togetherness of human-computer interaction and considering the role of artificial systems in production as well as their creative role in the evolutionary transformation of craft and performativity.

Outcomes, potentials, and limits with respect to the creative interactions and interfaces between novel subjective actions and productions can be described as means to be discovered in the redefinition of Subjectile. The networked architectural agencies and technologies further propose common conceptual mindsets for subject-artificial interactions. This investigation can be reinforced with multidisciplinary approaches focusing on the relation between the brain and AI (Appendix A). Some cognitive and behavioral concepts, in that regard, can be wrapped up in a logical looping structure through parameters of performance, imagination, affect, intelligence, decision making, creativity, adaptation, intuition, conscience, consciousness, and even judgment[17]. Thus, the evaluation of such key concepts in a critical manner further boosts the possible logical correlation in human-computer interaction[18] viewing the transforming relation between Subjectile and Objectile. The study concerns interpellation of the architect-subject with the rise of the artificial agents considering the common grounds of human-computer interaction. This related research focuses on mind/skillsets, which distinguish the thesis by considering the external dynamics of the built environment and the evolution from modernity towards intelligent spaces.

Together with the concepts mentioned above, as well as regarding the role of the action, intellect and instincts, performance and affect can be described as the primary constituents of an intelligent act of living behavior, as this is deeply questioned by Bergson in his key writings (Bergson, 1998; 2002; Marcuse, 1998; Picard, 2000;

[17] See also (Ballard, 2015).
[18] See also (Mitchell, 2003a; Bechthold, 2014; Sheridan, 2017) & Keith Evan Green, Architectural Robotics: Ecosystems of Bits, Bytes, and Biology, Cambridge, Mass.: The MIT Press, 2016.

Ballard, 2015). Accordingly, the attempt has been made to organize most of these concepts around the preeminent ones in this study, namely **performance**, **affect**, and **intelligence**. Aside from the distinct inquiry of creativity, these concepts are introduced to construct the coexisting modalities with the artificial agencies of Industry 4.0 for the potentials of Industry 5.0. The influences of performance are to be viewed in the transforming paradigm of Industry 4.0 in the design domain, with the rising expectations on non-standard production (Sorguç, Özgenel, Kruşa Yemişçioğlu, 2018) and with further possibilities of human-computer interaction environments. The rise of the 'digital twins' (Batty, 2018) (or electronic twins[19]) through a new understanding of neural networks and artificial intelligence, for instance, regards the recent potentials and even correlations among the creative and performative agents. Considerations of material and environmental experiences also imply the development of performativity, which apparently signifies the topology of the togetherness of humans, nature, technology, and the built environment. Hence, the research =regards the place of such correlations through the new paradigms of intelligent spaces and novel methods to make use of state-of-the-art technologies in architecture. As the new science in design, production, and experimentation of urban places through conceptual models of perception and growth, the performative correlations are considered with the condition of the individual and his/her collaborative networks.

In the section on 'affect', similar logical construction of the performance is followed through Picard's arduous studies on '*Affective Computing*' (Picard, 1997, c.2000; Jeon, 2017) to understand the significant role of affect in design and architecture by possible 'interactions'. Further intricacies between the nature of things, and the social, and virtual condition of the self in a networked social domain put forth the advanced considerations of how such technical grounds of science and technology in artificial agents' rising existence can be followed. This inquiry is exemplified with peculiar and initial examples from art, architecture, and urban scale projects such as having wearable devices, simulative learning environments, and even the grounds for artificial neural networks for crowdsourcing/crowdsensing. The vision of those studies leads

[19] Mitchell (2003b) also describes the rise of the networked infrastructure of artificial agents in cities, revealing the possibility of the 'digital/electronic' informational data for each tangible quality of the tectonic and spatial aspect of the digitalized city.

the experimentations with the dynamics and capacities of technology through the necessary understanding of affect and even consciousness[20] in architecture and technology when regarding even the tectonics of ornament with evolving Subjectile.

Hence, performance and affect construct the necessary logical bases to conceptualize a solid understanding of intelligence in its different aspects, especially regarding human-artificial interaction in the learning environments. Intelligence thus aims to program the progress of human-computer and nature (environment) interactions. The section on intelligence, akin to this, discusses the cognitive models by understanding the initial intellectual and practical attempts in architecture and the collective forms of creative agents that coexist with architectural technology as the organizational inquiry. Thus, the concept of intelligence extensively rehandles the problem of agency within the network of coexistent technologies and the probabilistic modes of decision making and creative action processes through performative capacities and emotional aspects in architecture. The challenges of intelligence, such as non-linearities in decision-making, will also be discussed in the following chapter(s).

2.2. 'Creative Performance' for the Intelligence towards Industry 5.0

Intensified integration of information technologies with evolutionary architecture (Sprecher, 2013) has exponentially augmented the symbiotic relationship between the form and its function to 'absorb' informational assets while relentlessly 'combining them' to guarantee their functional performance. The rising manufacturing like CNC fabrication has accompanied architecture's evolutionary transformation with the rise of informational technologies like *Designing Robotic Assemblies* besides the logical transformation and the rise of networked workflows/pipelines in Industry 4.0 (Ahrens, 2013; Bonwetsch, 2013; Legendre, 2013; Linder, 2013; Meier, 2013; Picon, 2014a; Brugnaro, 2016; Felbrich, 2017).

K. Eric Drexler[21] explains the dynamics of non-standard production in the fourth

[20] Roy Ascott's book has also ample examples searching for the relationship between art, consciousness, and the robotics (Ascott, 2000; 2003; 2006).
[21] K. Eric Drexler is the pioneer discoverer of nanosystems and their applications in nanotechnology. See also (Drexler, 1986; 1990;1992).

industrial revolution of the networked computational technologies' cooperation with "atomically precise manufacturing" (Drexler, 2013). In his analytical studies in *Radical Abundance* (2013), Drexler puts forth the progress among the knowledge fields of science and engineering that depends on theoretical growth and its application as a development pattern commuting between the matter and mind (Drexler, 2013)[22]. Closer inspections of design can be located at the intersection of the virtual potentials[23] and actual capacities of these circular as well as discrete and creative processes (Figure 2.1). The technological capacities and knowledge domain still stay within the borders of abstract space-time concepts to be expanded through scientific inquiries (Figure 2.1). Thus, the search for Industry 5.0 and beyond can only be achieved by exploring advanced space-time concepts and relative scientific inquiries that can be reflected in new technological possibilities (Figure 2.1). Non-standard production of Objectile, in that regard, not only implies the rising connection with scientific investigations but also gives clues about the future of Industry 5.0. Thus, further progress can solely be achieved by the rise of advanced inquiries on science and technology as in the recent itinerary between the imagination of design, virtual interfaces, and the (nano)science of 4D printing[24] (Figure 2.2).

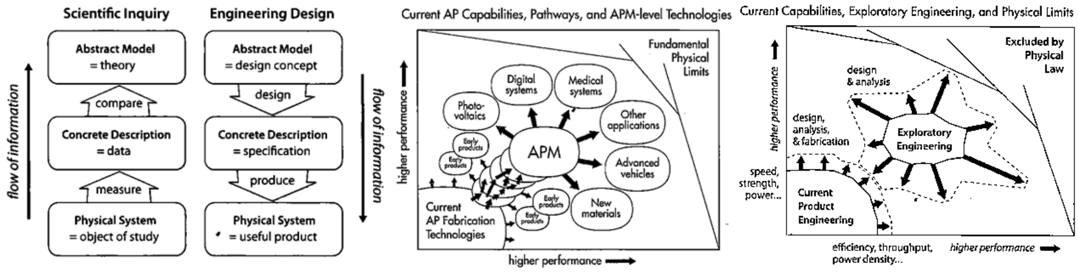

Figure 2.1. "The Antiparallel Structures of Scientific Inquiry and Engineering Design" (Left); "Pathways to APM-level Production and Products" (Middle); "Exploring the Technological Implications of Physical Law" (Right) (Drexler, 2013)

[22] The aspects of scientific inquiries, as well as the technological inventions, bear out the flow of information from actual to virtual and back again. The scientific progress from the analysis of facts of physical systems to the abstraction of theoretical models maintain continuous, as well as circular, hence, (creative) evolutionary processes. The industrial and informational revolutions, accordingly, propagate back to the reality of scientific inquiries by pushing the limits of everyday life physical principles (Figure 2.1).

[23] See also (Sorguç, Özgenel, Kruşa Yemişçioğlu, 2018).

[24] Skylar Tibbits introduced the technological advancement of 4D printing as a result of the teamwork at MIT MediaLab that materials take shape instantly with respect to the change of external/physical forces or through environmental interactions. Those interactions with their inherited coding like 'the DNA structure' are simulated by the special software development by Autodesk, Project Cyborg (Tibbits, 2014).

At this point, the question insists on how the architect can think/decide the perceptual stimuli of the environment, the material resources, manufacturing technologies, laboring bodies, the fetish of the commodity, and the production of real, habitable space as a decision-making problem all at once. Can the architect give creative and imaginative expressions to ideas about the way that people might live in the future while also manifesting on the collaborative, social nature of all architectural work? These arguments then ought to be seen as such: each design and production process should be integrated with creativity besides performativity (Deamer, 2015b) with 'integrated manufacturing', and each organization should envision the correlation between Objectile and Subjectile, as a part of problem solving[25] regarding the power of imagination. For that reason, the nearer future of architecture can be envisioned by understanding the rational as well as creative activity of the individuals in connection with the innovative bases of architecture and state-of-the-art technologies, even like neuromorphic computing chips controlling the networked agents, entities, interactions, and processes. The recent developments in human-robot collaboration in construction by signal processing of brain waves have revealed the uttermost technological progress implying Industry 5.0 for architectural practice (Liu; Habibnezhad; Jebelli, 2021). With the generation of intelligent environments and infrastructure, correlating sensations and decision making, Industry 4.0 has also emphasized the role of connected devices and smart spaces.

Figure 2.2. 4D Printing, by Skylar Tibbits, 2014 (Tibbits, 2014)

[25] See also (Newell & Simon, 1972).

To construct a common ground between the language of space-time and the advancement of science and technology, the practical aim is hence to present information technologies at the epicenter of the realization of abstract bodies of thought and knowledge in possible materiality. The experience of such materiality is proposed in cooperation and collaboration through the networked evolutionary deep neural networks, artificial intelligence, and other means of processing data; classified and regressed as modes of information that can become 'ordered' forms of produced knowledge. Moreover, the necessary shift from the rising impact of digital twins to the creative role of Subjectile by subjects' preferences and decisions reveals the potentials of crowdsourcing and correlational knowledge of human-computer interaction by new means of technology such as Big Data and the Internet of Things (Kocatürk, 2017; 2019; Berman, 2018) in addition to the rise of urban computing (Zheng, 2018).

Performance as an Ontological Question of Creative Act: It is possible to argue the emergent form of the networked organizations and collective clusters among architects (Latour, 2005) by understanding the scientific, technological, and theoretical reflections to surpass the abyss between practice and theory; the artificial and the natural; the biotic and abiotic. Such considerations reinforce the collective organizations of networked actors for socially diverse circumstances. The role of collectivity in actor-network theory and new interpretations of Subjectile relates to what Marcuse has drawn as the boundaries of performance principle (Marcuse, 1998) other than leisure or pleasure principle (Freud, 2001). The organization of labor has been separated into two distinct clusters for designing and manufacturing. Accordingly, performance seems to become a clause to initiate a discussion of work, labor, and energy to propose other complex relations such as the role of emotion or ornament in the digital culture of architecture. Thus, the 'ontology' of performance is the initial step with which to define the rational mindset of the networked agency of professional environments of practice and academia; this concept needs to be considered by the energy-related understanding of the new circumstances.

It can be defined that performance is an aspect of functionalism, technicality, and tectonics for buildings and environments to serve needs (Kolarevic & Malkawi, 2005), especially when the passing time is reconsidered in terms of being a rational matter of duration that is divisible into intelligible, computable segments. In this thesis, performance also corresponds to the phenomenal reality of the energy of things, structures, and actions with the common ground between architecture, science, and technology. Architectural things and subjects, even with their accompanied artificial twins, can be described according to their energy-related dynamics through performance and performativity, grounding for a new rational logic exempt from the disorderliness of chaos and complexity (Mitchell, 2003b; Frampton, 2010; Batty, 2018). The familiar concept of 'energy' also relates to the transforming self and society with technological and industrial revolutions since the energy need for daily activity has changed.

William Mitchell's description of humanity referring to Bateson's *Steps to an Ecology of Mind* (Bateson, 1972) signifies such evolutionary progress. Respectively, the human energy under the thermodynamic forces, balance, and entropy of information can be seen as the rationalized part of the agenda. The issue of design efficiency and the consideration of architecture on the basis of energy-related theories and concepts remind us that it is not only the energy that one individual spends during the daytime change (Smil, 2017), but also the scope and parameters that the architect should deal with have evolved. The compared energy levels are not the same as the ones in the eighteenth century. The influences of industrial revolutions have changed the agents' interactions in the market structures of production (Thomas & Amhoff, 2015). Additionally, the scale of design and production activity differs from the earlier design and production relations. There should be critical approaches against the division of abstract labor of the architect and the exact product of Objectile (Deamer, 2015b) as well, dwelling on the concepts of performance and energy for creativity.

The place of 'craft' and artisanship in architecture as a performative domain has hence also been explored regarding the possible capacities of Industry 5.0 (Frampton, 1995; 2010; Carpo, 2017). The discourse of craft can be reinforced by the human-computer interactions (of those 'Digital twins') between action and thought, between Subjectile and Objectile, between culture and technology regarding the physical materiality. This idea also stands to be reinterpreted to construct how subjectivity distinguishes itself as a rational performative actor from chaos (Frampton, 2010)[26]. It lies in the reasoning that novel computational technologies can even be defined under such propositions to become a craft of interaction as well as instant production (Ramsgard, And, & Tamke, 2013) towards Industry 5.0. Departing from the idea of craft as a critical term between making and knowledge, human and technology, Marble considers architecture again between design processes of imagination and production processes (Marble, 2010). Current information technologies hence find these relationships between human and machine intelligence. Accordingly, craft has turned into the design process, and its knowledge-based information flow, the drawings, and models do not represent something but are used to communicate directly via the means of fabrication.

The perception of risk in production by artisanship has also been changed and diminished by technology (Marble, 2010). Branko Kolarevic focuses on the topic of diminishing this risk (as the fact of Objectile) with the help of novel manufacturing by referring to McCullough's (McCullough, 1996) and David Pye's arguments (Pye, 1969) (Kolarevic, 2010). Therefore, parametric design capacities also enhance the capabilities and possibilities while decreasing that risk of work(wo)manship by defining the relationship between conception and representation (Goulthorpe, 2010). The fabrication process through the digital interfaces of the craft, on the other hand, controls the desired material outcomes, as the authors of information are again the architects, leading to concerns about performance on both sides of the material aspect and the design processes. Interfaces interacting with the reality of materials can be designed so that precision can be achieved with the help of digital/virtual media and state-of-the-art engineering of cyber-interfaces, networks of Digital Twins, robotic arms[27], and even by 4D printing. It even becomes possible to envision a procedure that can be issued for the argumentation of architecture within Industry 5.0 that enables constant changes of artificial agents via the interacting feedback loop of the interface and the new role of Subjectile.

[26] From Arendtian perspective, labor is a biological activity; work is an artificial activity, and craft in this distinction is a clue to point out an intelligent activity that the human subject distinguishes itself from the chaos (Frampton, 2010). Indeed, such a proposition reveals the modern character of design having a great deal of artificial activity in that distinction. On the other side, the psychology of design, by taking into consideration of rationality and emotion, is the part of that intelligence, which should be investigated closely.

[27] See also (Bechthold, 2014).

As in the cases of actor-network theory (Latour, 2005), the multitudes of agents (people and things) coexist in action collectively, even though this seems too controversial to be social; instead, it implies a molar togetherness of individuals to act on something. However, this brings attention to how we can rationally construct arguments about the ontological question of performance regarding the action and meaningful values attributed to the environment. Scrutinizing the arguments of work, commodity, and performative behavior is also necessary, indeed, as an ontological problem of the profession to identify performance to survive within the competitive grounds. As it predicates to act on something or initialize some thought, without performance other arguments and selected concepts are nullified and do not make any sense in terms of overcoming the previously mentioned problems of architecture and profession[28].

Re-framing Performance analogous to Creative Interactions in Architecture's Intelligence and Decision-making: Dana Ballard defines the act of creativity as a performative action that has never been previously learned or attempted (Ballard, 2015)[29]. By reading the creativity and necessity of the collective performance of the networked agent together with technological capabilities and energy and information-related conceptions, it is necessary to determine how architecture can be constructed together with creative artificial agencies and the new paradigm of scientific descriptions. Performative capacities of artificial agents and their creative role in information generation give freedom of production, manufacturing, and of its designer. Morel gives the initial example of *Universal House* (2012) (Morel, 2019; Carpo, 2013b), as William Mitchell (Mitchell, 1994) similarly develops his logic and emphasizes the scalable character of new modeling and production means. Furthermore, state-of-the-art technologies reveal that 'creative evolution' signs for the potentials of creativity of both humans' and artificial agents' differing conditions. It is utterly definite that we are not able to perform at the speed of computation for the emergence of idiosyncratic design objects and things without using the capabilities of technology. This gives the signs of upcoming technological revolutions with creative

[28] See also (Deamer, 2015b).
[29] See also (Gazzaniga, Mangun, 2009; Gazzaniga, Ivry, & Mangun, 2014).

capacities envisioning the evolution with its discrete and non-linear dynamics.

> "It is useless to make use of machines that operate at teraflop speed for the replication of what humans can compute at the rate of 10^{-2}. Machines that operate 10^{14} times faster than humans, therefore 'in regions of (computational) speed far beyond the capacities of humans' shall logically give birth to a kind of architecture that is also beyond our usual capacities. Such an architecture is still to be produced." (Morel, 2019)

Morel also discusses the hybrid togetherness of humans and the artificial in terms of a 'superintelligence' (Morel, 2019) that would potentially define a new mode of intelligence. Thus, creativity in the correlation of human-artificial agent togetherness and their dependent relations can be defined by certain likelihood functions. From nanotechnology to neuroscience, the drawn schema of the design between science and technology as a model (Figure 2.1) can be conveyed with its applicable protocols of performative aspects, giving life to thoughts of the rise of Industry 5.0. It is apparent that the new generation technologies of neuromorphic computers (Figure 2.3) can emulate the human neural system and exploit the means of probabilistic computing to deal with the problems of uncertainty and noise (Intel, 2019). What is crucial for the discipline of architecture and its professional aspects is the sensors enriching these technologies' transformation[30]. It is meaningful that these capacities can necessitate further coexistence and collaboration to enrich those collective networked-performative correlations and bring further possibilities of creative activity in the new descriptions/interfaces of Subjectile.

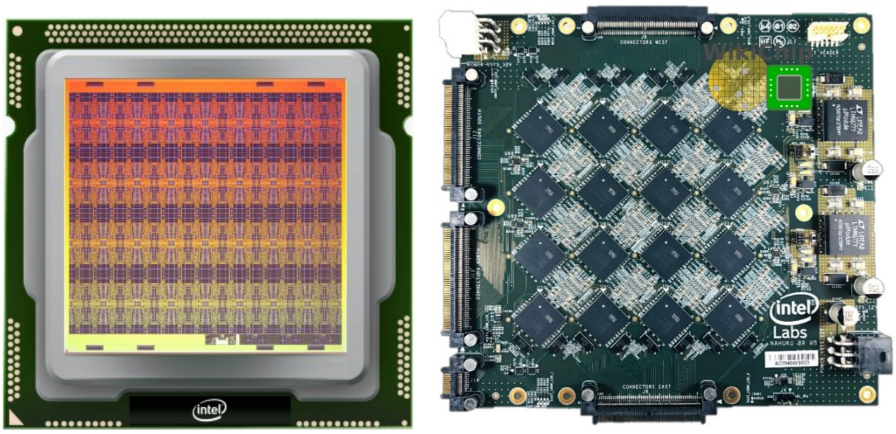

Figure 2.3. Intel's neuromorphic computing chip LOIHI, distributed first in 2017-2018 (left); Intel Nahuku board (right), including 8 to 32 Intel Loihi neuromorphic chips

[30] The capability of the connectionist system of these computer chips has self-sufficient hardware with the abilities of sensing and perception, just like a deep-neural network analyzing video frames.

Further development of creative technologies regarding design and manufacturing, as in the examples of BILL-E (Figure 2.4) and evolutionary algorithms for processing protocols (Retsin, 2019), can be correlated through proposed novel models of global parameters and procedures of collaborative networks. Design efficiency in the rising scale also relates to the new media's capability, decision making, and responsibility, even during the design process (Tombesi, 2015), as a performative act. New possibilities of "Digital Twins" of the artificial agents can be correlated as a behavioral pattern and as a collective formation (Figure 2.4).

Figure 2.4. BILL-E robotic platform, 2017, developed by Jennett & Cheung at MIT and NASA, MIT Center for Bits and Atoms and NASA Ames Research Center (Retsin, 2019), (Left); Nathan Melenbrink & Werfel, Robotic Ecosystem, Wyss Institute, (Claypool et al., 2019)

The dynamics of e-commerce, online supply-chain management, and data harvesting on the market scale redefine these correlations as "entanglement" in Subjectile-Objectile relations of non-standard design and production (Bedir & Hilgefort, 2019). Neri Oxman also regards the interdisciplinary coalescence of science, technology, design, and art as being "entangled" with each other and yet can be discretely realized by their particular roles according to the "Krebs Cycle of Creativity" (Oxman, 2016) (Figure 2.5). The reflection of such potentialities and models of correlation among science, engineering, and design on the field of production has also been explored by Bechthold and Retsin (Bechthold, 2014; Retsin, 2019).

Ubiquitous modeling of time- and action-dependent objects give the best examples of the discrete role of artificial agents such as robotic manufacturing arms taking over the task (Bechthold, 2014) to adapt and evolve to an ever-changing condition immanently. Artificial agencies in manufacturing, design, analysis, and responsive action (Figure

2.4) are among such performative inquiries in addition to the current capacities of connected design and production, such as 'atomically precise manufacturing' (Drexler, 2013). 'Digital twins' (or electronic twins) in all design and manufacturing processes, in this regard, represent the role of artificial agencies in correlation with the informational knowledge of the properties of the built environment, materials, and data in an urban milieu (Mitchell, 2003; Batty, M. 2018; Özdemir, 2019).

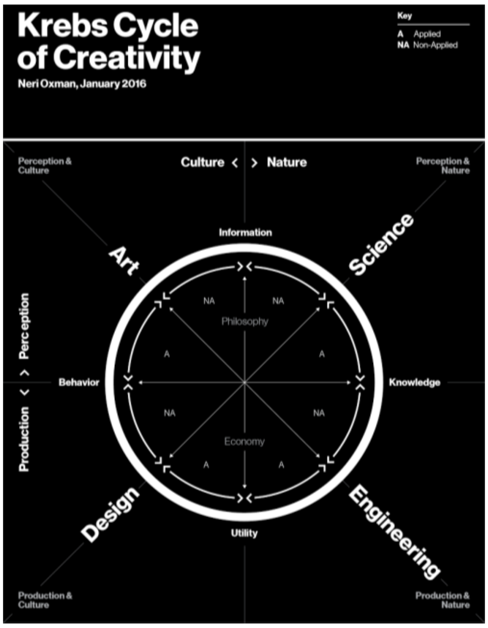

Figure 2.5. "Krebs Cycle of Creativity" revealing the entanglement among art, design, science, and technology (Oxman, 2016)

Advancements like brainwave-driven human-robot collaboration in construction (Liu; Habibnezhad; Jebelli, 2021) emphasize the apparent change in the logic revealing how the neuromorphic chips operate with the processed data of environmental as well as informational sources. Thus, Industry 5.0 ought to generate ties with architecture, and indeed it corresponds to the further development of science and technology through the emergence of neuromorphic computing technologies. On the other hand, the utilization of the technological potentials of artificial intelligence (of neural networks) in the capacities of Industry 4.0 still has the potential to deal with the complex forms of curvatures and intricate shapes. Seemingly, it does signify further development by requiring the harvest of Big Data. IoT and crowdsourcing within the inquiry of the complexity of design and the dynamics of the urban environment and even the generic studies on economy (Zaera-Polo & Munitxa, 2013), hence require that we direct our efforts towards the new way of processing information[31]. Hence, these methodological endeavors might call architecture a learning profession, embracing technology towards the revolutionary bases of interaction with respect to the rise of artificial intelligence models. By 'live programming', these interactions become possible with the recent so-called online learning and computation[32]. Such an approach can also provide the physical experience of the materiality of the environment. Thus, the ultimate definition of architectural intelligence should be derived from the human interaction with the artificial as well as by the materiality and the tangible form in its ultimate sense.

According to Hight and Perry, "Collective intelligence" incorporates discrete unities, and connects each agent of design and action to the other to address a particular goal as a networked relationship (Hight & Perry, 2006a; 2006b). The idea is also explored by how particularities can be incorporated and become collective around the performative tasks through these networked relationships. Bruno Latour explores this idea in his book '*Reassembling the Social*' (Latour, 2005), which establishes what actor-network theory is. It does propose the generation of a new social intelligence that is organized around task-related activities. According to Hight & Perry, such networks should also provide sensorial and communicational technologies (Hight & Perry, 2006a; 2006b). This endeavor can generate fully connected, sensorial, and correlational agents and environments; whether they are artificial, individual, or social agents, they are expected to be a part of a material experience.

According to this, it can be said that sensorial networks follow the path of catching performative aspects and progress towards the form of intelligence. Judgment about this progress can be assessed by the logic of social and computational belief systems[33] as the collective being of elements, agents, concepts, and the substantialization of materialities. Indeed, this recommends the togetherness of the biotic and abiotic

[31] Accordingly, the probabilistic conformational maps, the energy landscape of the moving agents in their immediate environment, or the usage of perceptron(s), neural networks, Bayesian networks, hidden Markov models, and other complex models like Monte Carlo methods (as they are capable of treating protein-folding problem) are in the way of further development for decision-making models.
[32] See also (Ng, 2017; Erişen, 2018a).
[33] Regarding all the aspects of performativity, creativity, intelligence, networked and discrete agencies, and environments, it is to propose a further logical/computational loop re-iterating over those elements by taking them together under the proposed modalities of the intelligence for human-computer interaction.

substantializations towards the necessities of Industry 5.0. The thresholds for developing substantial intelligent environments have already been surpassed in demand, and require closer inspection of the relationship of architecture and its agency with the environment, science, technology, and industrial development.

Three different aspects with respect to these arguments can be implied regarding the role of subjectivity towards Industry 5.0. First, it is the intimate link that we experienced in the physical world through augmented reality. Additionally, the materiality of weight and inertia and its phenomenology of matter, even in the new condition of the craft, enables us to grasp the transforming relation between Subjectile and Objectile. The second concern about the question of Subjectile is regarding the individual preferences, choices in digital culture, personalized data, and interests. The third is rather about occurrences, events, scenarios, and actions, as expected performances, at the scale of intelligent environments; and at the urban scale with many networks, media, and tools, like reimagining the Situationists in Industry 5.0.

Respectively, the political consciousness is also needed to ponder utopia and remembrance to reveal the unconscious in the conscious act and play. Throughout these arguments, the relation of architecture with information 'requires to grasp the production and design relations converging at the technological advancements in transformation' regarding the role of creative act and decision making. The new mindsets for the agency of architecture are crucial to discern the dynamics and circumstances of the information age's conceptualizations by scientific inquiries and space-time experiences.

Describing Performance in Architecture: Hensel categorizes the corresponding literature on performance and architecture into five main concepts (Hensel, 2013). The first idea focuses on the relation of mind and body to focus on representation, symbolism, and meaning from the 1960s to the present day, including the discussion of post-modernism, as Jencks does (Hensel, 2013). The second stream reconsiders the first, and is related to the current condition that led to the new tectonic arguments and concepts of 'free skin' (Hensel, 2013). This also leads to the contradistinction between contrast and unity with regard to the arguments about form and function. The third approach carries contradistinction between art and engineering yet locating the design in between (Hensel, 2013). The fourth concept focuses on events, considering usage and random actions realized within architectural environments like the architecture as an event, as Tschumi speculates (Hensel, 2013). The fifth concept dwells on the relationship between planned and unplanned performance (Hensel, 2013) regarding environment and intention. In short, the fifth domain concerns the human-environment interaction as a performative issue, as Reyner Banham also seminally introduces the relative environmental parameters as well as the performance of materials (Banham, 1969; Menges, 2011; 2013; 2015a; Kolarevic, 2015; Menges & Reichert, 2015). As an obligation to the society and profession for balancing the sustainability between the human-made and the natural by the theoretical framework and the everyday life practices (Hensel, 2013), strong determination of performance in architecture thus needs an overarching, unitary and coherent approach from various standpoints.

The general perception about the performativity of architecture results from the contemporary anticipation of the strength, durability, and functionality of things (Kolarevic & Malkawi, 2005). On the other hand, the subjective aspect of performance can be defined as the capability to realize action and transform energy into work by different means, skills, and capabilities of mental and bodily activities (Hensel, 2013). Thus, Hensel explores the things and subjects with their performative capacities, collective, and social dimensions within actor-network theory (Hensel, 2013). The different bases, ranging from the nature of subjectivity to the energy-related inquiries of science (Hensel, 2013), define the design as a biological (ecological), environmental, and cognitive problem beyond the representational aspects[34]. Then, the relationship between the agency and (its) performance makes it necessary to distinguish the aspects of the individuals and their creative production activity as Subjectile from those of the artificial.

As already mentioned in the actor-network theory, things should be regarded in the continuum of complexities, so as not to violate creativity and coexistence but to be seen as interlinked dynamics. In that theory, the distinction of humans from the artificial can be proved by recognizing the intentional acts of living behavior by state-

[34] Development in architecture with regard to the theme of evolution, with respect to this search, can also be seen as considerably influenced from biology of the 18th and 19th century to 20th century systems theory even regarding the role of the bio-politics, biotic, and abiotic environments.

of-the-art technologies, gauges, and methods[35]. Carpo argues that Living (human) behavior traces its labor force on things such as craftsmanship (Carpo, 2017), defining the domain of Subjectile; yet even this could not be tested with the new thresholds of artificial agencies. In this study, however, the research dwells on the performance of correlations of Objectile-Subjectile relations in the seminal studies of 'Digital Twins' in architecture. Studies on the common ground between artificial systems and humans are vital regarding attention, memory, perception, sensation systems, complex decision mechanisms, and their associative models. Zak gives creative examples of how natural and artificial agencies can be grounded on the principles of nature and how they differ (Zak, 2011). Respectively, Zak's seminal ideas and experiments give way to understand the peculiar character of Subjectile when it is tested again in correlation with the informational thresholds of Objectile in the rise of artificial intelligence in architecture and production. For example, it is possible to construct some associative models between the artificial and human agents on the same experimental sets by which the artificial neural networks would be trained. Such associative models can correlate the shared data between the human and artificial agent (Zak, 2011), grounded for perception in architectural design, production, and construction. Tried to be described as the 'Digital Twins' in the design paradigms, this becomes intelligible even on more extensive scales, and distinguishes the intricate behavior pattern acquired from monitoring each agent's behavior. Then, it can also become possible to discriminate the monitored data of the related individual agent.

In one of the more recent attempts, Digital Twins were trained with the AR interfaces and by real-time correlation of the learning models (Kyjanek, Al Bahar, Vasey, Wannemacher, & Menges, 2019) that synchronize the action of the subject with the robotic work cell on the assembly pedestal, implying the new potentials of Subjectile (Figure 2.6). These protocols do channel the upcoming external data, such as operating on the CAD geometry and angular production details. The input from the user interface is controlled by Microsoft HoloLens (as the AR agent), as well as the user's

[35] Michail Zak seminally demonstrates the distinction of the natural behavior from the ones of the artificial agents by assessing the discrete directions in the frequencies of these behavioral patterns (Zak, 2011, p. 163). Nevertheless, the co-existence of artificial agents with individuals and natural beings is also a radical potential of the discrete creativity of artificiality. Zak also demonstrates the potentials of mathematical abstractions and the boundaries between the artificial and natural agents (Zak, 2011).

computerized CAD data converted from Rhinoceros + Grasshopper and the downstream visualization by graphics on web interfaces, are also included in these systems (Kyjanek, Al Bahar, Vasey, Wannemacher, & Menges, 2019) (Figure 2.6).

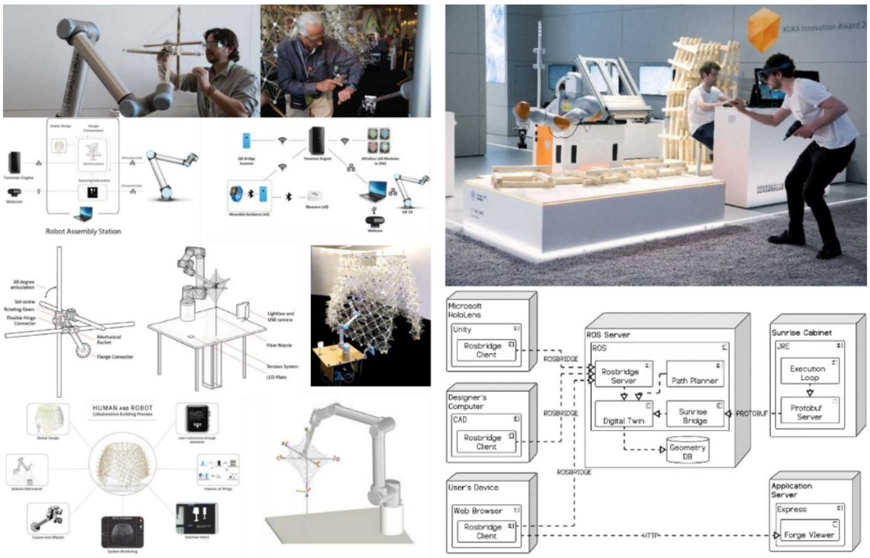

Figure 2.6. Human-computer interaction/collaboration in construction (Vasey et al., 2016), (Left); Applied models of Digital Twins (Kyjanek, Al Bahar, Vasey, Wannemacher, & Menges, 2019) (Right)

Moreover, it is very significant to expect crowdsourcing studies via those technologies by getting the preferences, choices in digital culture, personalized data, and individuals' interests. Such inquiries can also contribute to the new way of generating models of workflow, decision making, sustainability, and understanding the associative principles to be worked between the human and artificial agencies to comply with each other effectively. These studies also regard the rise of novel technologies in computing and the facilitation of energy-related performative aspects in the built environment (Yadav & Panda & Hachem-Vermette, 2020), such as neuromorphic computing chips. These studies may also include concerns on consumption, occupant behavior (Schweiker et al., 2020), and environmental patterns besides the energy-efficient usage of facilities. The role of artificial neural networks and intuitive prediction and computation by artificial intelligence is thus increasingly gaining in importance (Afram & Janabi-Sharifi & Fung & Raahemifar, 2017; Ahmad & Mourshed & Rezgui, 2017; Westermann & Deb & Schlueter & Evins, 2020).

The web-based configurations to handle the collaborating data are crucial to imply the potentials of the Subjectile (designer/user preferences, updates to models by crowdsourcing) and the artificial agencies with their togetherness and their separateness online to the manufacturing. The proposed interfaces between the 'digital twins' of the architectural and urban environments are parts of developing hypothetical models, increasing the focus on affect and intelligence by understanding the perceptual correspondence of consciousness and awareness through the mirror stage (Figure 2.6). Image-space and its further interpretation in phase space/differences (Zak, 2011, p. 242; Yang et al., 2020) can hence further be described among those potentials, so that the intricate nature of subjectivity of self-consciousness would reveal and can be reinforced with further artificial interactions. Such programmed processes can enable humans to interact with robots and make robots send feedback to the ultimate designer. These peer-to-peer interactions can be enriched further around the ecological and experimental urban environments and platforms such that the correlation between the networked natural and artificial agencies can generate common sense and informational knowledge of the new era. Accordingly, it corresponds to the 'axiomatic' essentials and semiotic and semantic principles of interactions through the new discourse. This might be an opportunity to express the inner sense and its action of production and the intelligible artificial logic scripts by common creative methods.

Creative Methods for Performance in Subject-Artificial Interactions and its Spatiotemporalities: The practical aspects and corresponding methodologies in the interaction between human and artificial agencies refer to the evolutionary dynamics of technologies for the creative self and collectivity in architecture, though with some challenges. The rise of neuromorphic computer chips, for instance, indicates the two challenging conditions in the inquiry of the advancement of human-computer interaction in architecture. The first challenge refers to the new means of software applications for processing data to develop new 'interfaces of computational logic' when compared to classical computation's internal dynamics, ascribed here as the 'blind logic of classical computation'. Apparently, classical computers and software cannot process the sensorial data but only convert the inputs into numerical formalisms and then the representational means for the running code (Appendix A). The other challenging question is about the real potentials of new hardware resources. New technologies enriched with sensorial attractors and inputs augment the search for humanized technology (Fromm, 1968) and its substantial reflections in production. The togetherness of the two challenging questions can lead to novel correlations between the different performative models of human-computer interfaces/interactions.

Thus, the first challenge can be seen as an impasse for the hardware of classical computers in processing the flow of sensorial data. There can only be ways to develop further models and diagnostic software, besides the existing ones for customer experiences, to predict architect's design decisions and the enumeration of the learning algorithms by listening the design activity and procedures. One merit of this approach can be claimed to be the development of novel representational workspaces/interfaces. The reverse computation of the recognized input through neural networks and likelihood correlation models is another creative method to decompose each action and element in learning against the first challenge. The recognition of things and elements of thought in this way necessitates a unique search for values and amplitudes shared between the subject and computer logic. This search is also strongly related to the correlation of human and artificial in artificial neural network studies that can only be understood better by the second challenge.

On the hardware development side, as the second challenge, the discussion comes to argue the humanized technology in architecture for the efficient usages in the custom domain of performance in design, production, and human-artificial interaction. Respectively, this concern questions the direct recognition of informational object-based inputs. In the rise of state-of-the-art technologies, the focus would be more about the subject-based responses learned via wearable devices and intelligent spaces, VR, and AR technologies, rather than solely developing representational workspaces. The substantial growth of new technologies, like deep neural networks via RNN and LSTM models, new generation computers and the futuristic possibilities of molecular computing, and novel media of photonic and optical computation techniques, all offer further possible means of recognition of the exact sensorial inputs (Erişen, 2018a).

The corresponding correlations by the synthetic logic between the human and computation can even be simulated concerning the two challenges mentioned by the thresholds of performative activity (Appendix A). Thus, this section can be seen as preparation and development of complementary modalities and performative mindsets with biopsychological inspirations in order to elaborate them with artificial models and their real-time applications. It is possible to get the parameters by selecting the ground truth about the subject or the artificial agent and by comparing the results of interaction and multiple agencies' performance results by keeping the *a priori* evidence determined either with regard to the subject's or artificial agents' actions or data from the belief system. The research between human-computer interactions, then, can be directed towards multitasking with multiple agents in real time.

Associative models between the artificial and even human agents can be found with the help of metaheuristic algorithms and likelihood functions[36]. Further reinforcement to these correlations and associative models can be offered by the creative coexistences between human-artificial as well as artificial-artificial agencies like 'Digital Twins'. Some examples of creative methods in selecting and developing features or aspects shared between different agents could further enrich this argument (Appendix A).

The control set of selected methods can make such generated models[37] evolve by swapping features of lower strength/probability with good ones via crossover, selection, mutation, and adaptation of data (and even error correction) with their respective association to the action and likelihood functions (S. L. Brunton & Kutz, 2019). Features here can also be seen as generative for various rates and parameters of performance and productive action. Data values, for instance, can represent the efficiency of object detection, or the possibility of remembering one element by artificial neural networks for architectural software. What can make this abstract logic on the nature of things of further interest is the possibility of using these strings of the genetic algorithms[38] to develop parameters and features of 4D printing as 'the artificial' strings/filaments[39]. Furthermore, similar creative models can be generated for synthetic logical reasoning, or even for drawing by scripting codes on platforms that run genetic algorithms themselves, or even for crowdsourced data of subjects for new parameters of Subjectile other than computational aspects. In short, such creative

[36] Genetic algorithms can help to develop other potential models.
[37] See also (Dierichs, Angelova, Menges, 2015; Schieber, 2015; Thomsen, Tamke, Gengnagel, Faircloth & Scheurer, 2015).
[38] See also (Frazer, 1995).
[39] See also (Doerstelmann, Knippers, Menges, Parascho, Prado, Schwinn, 2015; Doerstelmann, Knippers, Koslowski, Menges, Prado, Schieber, Vasey, 2015).

methods and methodologies can be practical for defining the future of Objectile, and the subjective decisions and parameters for Subjectile. The study aims to draw a much broader scheme containing many possible variations and parameters to generate 'topologies of data'. Therefore, it can be any other type of activity or action that can belong to artificial as well as human agents and these different domains. Finally, they can establish the correlation between humans and computers (or different artificial agents) on different platforms and interfaces by learning sensorial environments.

Processing complex elements of thought for the creative production and computation and some intuitive, as well as representational (semantic) interactions, correspond to the cognitive and behavioral studies on the one hand; on the other, the artificial agent can generate more flexible artificial neural networks to operate actions through different learning models of both supervised and unsupervised learning as even achieving discrete or continuous learning patterns. The associative models between different agents' network processes would give handful results to increase performance. Discrete networks of humans and computers, for instance, enable us to focus on the same activity with similar network patterns to provide specific correlations between the artificial (such as neuromorphic chips) and natural agents (Appendix A). These models can also be discretely modeled by the same event handling to generate 'creative' Digital Twins, yet they will generate conjunctive and disjunctive reference bases that will be analyzed in the following chapter. Processed correlational data via artificial intelligence can also be acquired from social networks and environments, which may become ecologies for the Internet of Things (Kocatürk, 2006; 2017; Bouhai & Saleh, 2017; Geng, 2017; Stokols, 2018).

Such modalities, however, cannot be constrained with virtual informational models but can also be grounded upon the reinforcement of direct manufacturing and production in the correlation of Subjectile and Objectile or in the multi-existence of artificial agencies. It is even possible to correlate the different fabrication agents such as the ones of robotic arms that operate with tactile sense on the one hand (Lumelsky, 2006), and those that run with the visual data on the other via the development of informational interfaces. The rising paradigm of 4D printing, the evolution from self-assembly towards evolutionary structures (Papadopoulou et al., 2017), or 'new means of 3D printing in motion' can further be proposed to develop novelties in production and design for the multiplicity of action and networked agents.

Then, the necessary step is to explore how the living and artificial agent interactions and their traces on the environment can be founded with the new potentials of technology on a larger scale. Schumacher claims the reflection of the performative aspect of technological, cognitive, and even epistemological grounds on the occasions, events, scenarios (action), with the expected performance at the urban scale and crowdsourcing (Schumacher, 2011a; 2011b; 2013). He regards the self-replicating mechanism of theoretical and practical progress for the profession of architecture[40]. The socio-cognitive dimension of performance analyzed by Schumacher (2013) starts with the precondition that architecture is to be regarded as a social and communicative frame of interaction. Societal evolution with that of the simultaneous ordering of space separates and connects social actors with their activities as a societal memory (Schumacher, 2013). The built environment is a material substrate and plane of inscription, as the habitat of that evolution, as a social life, as the physical means of crowdsourcing. As a system of distinctions and relations, the system of social settings uses the positional identification of places (spatial position) and morphological identifications of spaces in societal information processes (Schumacher, 2013).

The performative density proposes that everything else must resonate with everything else in the urban field as an informational richness, cognitive coherence, and effective participation in a complex milieu for the simultaneity of events and communicative encounters. Thus, the perceived threshold becomes much more important than the physical barriers and channels (Schumacher, 2013). It requires considering the associative logics correlating the different urban and architectural subsystems as a problem of representation, or fuzzy identities/identifiers and determinacy of things. Hence, the organization is based on the distribution of positions for spatial elements and their pattern linkages. Their articulations are based on the morphological identities, similitudes, and differences across architectural elements like the design of a coherent visual language or system of significations (Schumacher, 2013).

[40] It is to report that such a theoretical basis is again inspired by different disciplines such as biology and sociology.

Lehman further argues about the speculative togetherness of the networked social agencies with the intelligent built environment. In the *Adaptive Sensory Environments,* Maria Lorena Lehman gives the theoretical basis for how novel technological spaces can be designed in direct interaction with the subject agencies and in a natural or artificial environment as an open system (Lehman, 2017). She follows the arguments of automatism and the growth of self-replicating things with their performative networks, responsivity, and adaptation. Thus, *Adaptive Sensory Environments* can be seen as the probability space of Industry 5.0, proposing even the correlation of the individual's neural activity with the responsively designed environment of architectural spaces (Liu; Habibnezhad; Jebelli, 2021). In light of this, this study looks for the theoretical framework, and technological, innovative, and scientific bases to implement similar systematic approaches in design and interaction in the built environments.

In this research, performative behavior has been argued to be the inevitable mode of action for the subject of the information age. Indeed, some performative design action starts again with the determined thought of imagination and the habitual experience[41]. The performative progress includes a transference between the matter and mind, and has a series of cognitive and perceptual behavior. Those processes emphasize the progress of Industry 4.0 to get the relation about how novel revolutionary grounds such as the search for human-computer interaction can envision Industry 5.0[42]. Experimental and clinical studies of scientific inquiries in neuroscience and psychophysics for performative assessments implement the common artificial logic of computation to develop the technological grounds between human and artificial agents. Thus, the progress of performance can be ordered in an array of the informational cell of actions of imagination and perception, learning and understanding, and sensory-motor and kinetic actions besides the judgment with decision-making processes including the role of emotional disturbance and affect. These concerns have gained popularity in recent years with the development of artificial logic of technology and computational science.

[41] The brain's left lobe is more responsive to sensual experiences, while the right lobe is much more accustomed to the imagination. See (Akhundov, 1986).
[42] Please also look at William J. Mitchell, *Me++. The Cyborg Self and The Networked City*. Cambridge, Mass.: MIT Press, 2003 on the rise of the networked infrastructure of artificial agents in cities & Keith Evan Green, *Architectural Robotics: Ecosystems of Bits, Bytes, and Biology*, Cambridge, Mass.: The MIT Press, 2016.

2.3. Architecture with the Domains of Affect

Mostly disregarded or missed in computational studies[43] and in architecture's rational modernist culture in the majority of CIAM congresses, the place of creativity with emotion and their informational processing has been mysterious and even challenging for the linear logic of computation and design practice. This study aims to reconsider agents' performative actions with their 'internal/intrinsic' subjective behaviors in relation to emotional decisions. Therefore, the sensual and psychological 'Affect' can be analyzed with the ability of conscious decision making and judgment under the influence of instincts, and sensual and emotional experiences (Bergson, 1998, pp. 176-186; 2002). On the side of collectivity, the correlation between the biological and technological has gained prominence, including the interaction with the environment through art and form, as McLuhan described in the 1960s (Erdman, Gow, Carlson & Perry, 2006). The transformed recognition of one individual through the aesthetic perception of architecture can also be reconsidered as a groundwork for the new possibilities in artificial agents' aesthetic perception, as 'post-human' (Hays, 1992).

Within the interlocking flux of human-computer interaction of the actual and virtual architectural design and experience, Affect becomes vital to distinguish the cognitive and sensorial activity of 'intelligent behavior' of subjectivity, especially in Subjectile, with its emotional responsivity. Bressani describes the experimentation of architectonic qualities as the planar membranes of interaction or the atmospheres with thermodynamic qualities as in *Blur Building* or *The Weather Project* (Bressani, 2013, pp. 323-329). Experimenting with the forces of sensorial stimuli and activity of architectural surfaces mostly activates haptic sensations.

The emergence of 'psychic energy' by the interaction occurs at the very surface of the screen of the artificial agents with the flow of information as a new mode of spatiotemporal 'deterritorialization' (time-space dissipation/expansion) that has become the subject of analysis since the 1980s (Green, 2016). Affect is imperative to consider the current phenomenon of subjectivity throughout the human-computer interactions as a

[43] The centuries-old thoughts on the role of subjectivity concerning absolute space-time are the missing parts of the investigation of human-computer interaction and its smart environments.

promising field of research in the information age under the potentials of Industry 5.0. As a considerable domain of behavior to reinforce artificial intelligence via sensual and emotional reactions (Tettegah & Noble, 2016), Affect enables to come up with the humanized technological agents via the inquiry of subject-artificial togetherness in the age of artificial intelligence (Vallverdu, 2015). The focus on affect in the interaction with digital interfaces can also guide the sensual experience of humans in the light of the machinic propositions of the new logic. The mentioned inquiries on affect, consequently, envision the intelligent collective behavior of human-computer cooperation as well as the social behavior among human and artificial agents.

One of the most influential and inspiring studies with theoretical background has been carried out by Rosalind W. Picard in *Affective Computing,* analyzing the factor of emotion in computation as well as in environments (Picard, 1997, 2000; Jeon, 2017). Respectively, she starts with the inquiry of whether machines can have emotional intelligence or not as she proposes emotion to be a part of intelligence that is active in perception, thinking, decision making, and creative actions. According to her, intelligence cannot be evidenced without emotion/affect as it also interferes with social interactions (Picard, 1997; 2000). While computers do not have the ability and necessity to have emotional states/perceptions and reactions, Picard takes on the mission to develop a substantial form of intelligence that gains the ability to respond with human-like behaviors and modes of thinking to the environment through her studies at MIT MediaLab. As she argues, such projects also require logical skills and reasoning capacities of performativity first to survive and gain robust, reasonable, and intelligent responses and the necessary dynamics of stability with the capability of balanced intuitive awareness.

Picard puts forth the critique of classical computation that lacks sensorial organization so that there should be atomically precise computation means established. The intricate shifts that are caused by emotional disturbances and consequences of affect on a body/system can delineate a process, as she notes: “Computer-based communication is affect-blind, affect-deaf, and generally speaking, affect-impaired. A quantum leap in communication will occur when computers become able to at least recognize and express affect.” (Picard, 2000). However, such a fragile balance should be developed upon each emotional activity concerning physical and cognitive aspects and interfaces in-between by their identification. The general assessment of those feelings is achieved by pattern recognition and heart rate, breathing, blood pressure, muscular, and other bodily activities to be monitored in learning progress and converted into processed data (Picard, 2000). Reasoning capacity is another concern that became the subject of research fields ranging from cognitive and computational neuroscience to psychophysics. Further considerations of human-computer interaction models question the social and even cultural capabilities to conduct intelligently. Nevertheless, such proposals can still be seen as challenges to computational and behavioral sciences responsible for determining each biotic and abiotic agents' energies and identities and the other dynamics of the environment that become a simulative project of Life itself[44].

Such propositions also enable us to understand the dynamics of Life and in which ways artificial agents can be more helpful to the creation of new actions in the built environment that have never been previously experienced. For example, visualizing or documenting, and proposing predictive models on the emotional states of human agents would be enough to consider a collective network model that can generate 'assembled collectivities as a mode of intelligence' that focuses on certain performative tasks. Affective devices can also be utilized to increase the human agent's performance, such as the augmentation of the emotion associated with memory or additional sensorial data and possibility of the collective sensorial networks on artificial platforms, especially with the help of wearable devices (Picard, 2000). Hence, a computer can (statistically) recognize emotion without necessarily having feelings (Picard, 2000). On the other hand, Picard also describes the usage of artificial agents for more necessary tasks and what is inspiring to the scientist to think about the relation of feelings and computers:

> "In 1962, Masanao Toda, a Japanese psychologist who emphasizes the importance of studying whole systems, including perception, action, memory, and learning, proposed a scenario with a "fungus eater," a humanoid robot, to illustrate how emotions would emerge in a system with limited resources operating in a complex and unpredictable environment (Toda, 1962) …The robot has rudimentary perceptual, planning, and decision-making abilities. With the inclusion of "urges", which Toda defines as "motivational subroutines linking cognition to action", Toda argues that the robot would become emotional. According to Toda, urges come in two flavors: emergency urges, such as fear, and social urges, such as love... Toda's proposal has influenced the AI community by emphasizing the emergence of emotions in complex goal-directed autonomous

[44] Inspirational scientific studies by Zak and Picard also focus on this issue by including emotion with the formidable forces of environment and Life regarding sigmoidal non-linearity (Zak, 2011; Picard, 2000).

systems." (Picard, 1997, 2000).

The models of human-technology interactions and AI's future: The current capacities of neuromorphic computing reveal the self-sufficient hardware to develop their sensing and perception in time without supervised training. Intel announces the current neuromorphic technology as the future of artificial intelligence. Intel's or IBM's new neuromorphic chips try to mimic the spiking neuron about the development of further artificial agents and assessment of sensations/states by human-technology interaction models (Davies, 2018) as well as attention and the learning mechanism of natural brain functions. These developments should also be analyzed by setting thresholds and plasticity ratios and certain attractor points in the change of those gradient functions for learning and other neuromorphic abilities. The merits of neuromorphic computer chips, in that regard, can be developed for the probabilistic prediction and learning models; indeed, over long durations, they may mimic the human brain system. In light of the considerations of consciousness and nature, however, there are ways to go further even for these technologies as they may not even ultimately give expected results due to the nature of things, in essence, revealing the NP-complete challenges.

Nevertheless, it can still be argued that those state-of-the-art systems are yet to be developed concerning environmental and thermodynamic aspects when viewing the living behavior's genuine nature. When considering living behavior, Michael Zak argues that subject agents as social and cultural members have a somewhat fuzzy description of restricted goals in thermodynamic/environmental systems while evaluating emotional aspects with performative tasks (Zak, 2011). Zak defines a gradient function of changing emotional states "$\mathrm{E} = \mathrm{c}\,(\mathrm{v} - \mathrm{v}^{\dagger})$" (Zak, 2011, p. 173) that should be considered for the task-related energy of affect (Zak, 2011) in human-computer interactions and artificial intelligence that can be deployed in architecture.

Another significant aspect about interfaces to reveal the intricacies of Subjectile is the "collective mind" regarding the development of models according to the achievement of a form of intelligence (Bergson, 1998, pp. 186-271), as a level of common sense among different agents, proposing to mimic the ones of individuals (Zak, 2011, 189-205). The integration of emotional factors to be evaluated within the external and social environments is designated under the hypothetical models proposing "collective mind" as a register of mental and motor dynamics (Zak, 2011)[45]. To sum up, one artificial agent, to acquire the emotional capability of awareness of itself in social and collective environments in human-computer interactions, should have:

> "1. Transition from disorder to order autonomously,
> 2. Capability of generalization and abstraction,
> 3. Capability to generate complexity autonomously.
> 4. Capability of making common-sense decisions.
> 5. Capability of self-supervision and control (such as control of noise)." (Zak, 2011, p. 243)

To overcome the ethical issues of human monitoring by artificial devices, artificial neural networks and learning models that mimic natural behavior help derive the parameters for defining what Subjectile could be. For instance, training artificial agents with the same architectural image series that human agents perceive could be one method. It is significant that there are differences in the human and artificial agents' stimuli and responses, even in distributing those responses when regarded as correlational. Zak attributes to *biosignature* (such as self-image and self-awareness) that are to be distinguished with its chemical and biological responses having specific directionality of living behavior assessed through time-series data when compared to a non-living behavior (Zak, 2011, pp. 162-166).

Nevertheless, Zak once again asserts that it would not be a fully constrained factor for his proposed model to simulate the living behavior[46]. He implies the benefits for how such considerations are distinctive from the natural/individual being. According to him, the natural agent can evaluate the self-image that is naturally inherent for itself, making the agent also be able to evolve to predict instant events (Zak, 2011)[47], which is crucial to redefining the role of Subjectile in the rise of artificial intelligence. In that

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[45] Those dynamics are modeled as attractors and repellers to testify and process the associative modalities (by self and non-self images) (Zak, 2011, pp. 161-187). Their evolutionary progress regards the tasks of predictions of the future and making decisions and updates to the plan (belief system) regarding the unexpected events and the function of emotional changes.

[46] "It should be stressed that the proposed model is supposed to capture the signature of life on the phenomenological level, i.e., based only upon the observable behavior, and therefore, it will not include a bio-chemical machinery of metabolism. Such a limitation will not prevent one from using this model for developing artificial living systems as well as for studying some general properties of behavior of natural living systems." (Zak, 2011, p.166).

[47] "a non-living system may possess the self-image, but it is not equipped with the self-awareness, and therefore, this self-image is not in use. On the contrary, in living systems the self-awareness is represented by the expectation-based control forces that send information from the self-image to the motor dynamics. Due to this property that is well-pronounced in the proposed model, an intelligent agent can run its mental dynamics ahead of the real time… and thereby, it can predict future expected values of its state variables… Such a self-supervised dynamics provides a major advantage for the corresponding intelligent agents, and especially, for biological species: due to the ability to predict future, they are better equipped for dealing with uncertainties, and that improves their survivability." (Zak, 2011, p.173).

regard, it is crucial that neuromorphic computing chips be evaluated as the artificial agents to be deployed for such tasks, as they learn like humans. Yet, they are distinct as they do not learn in the exact systematic (metabolic) processes. Hence, affect is to be questioned over the separation of object and subject so that better logical connections can be created. Regarding the issues of predictability and unpredictability, affect characterizes the contemporary age's subjectivity. Picon says: "Duality between the potential and virtual in the information age leads to the coexistence of simulation and scenario; and performative action by architecture regarding environmental sustainability to sensory and emotional effects" (Picon, 2010).

In architecture, Carpo similarly notes the distinct nature of living behavior by emphasizing the craftsmanship of the artisan culture[48] in mass production and customization (Carpo, 2017). The difference between how computers and humans sense emotional states differently (Zak, 2011), on the other hand, reveals the roles of associative learning models between the natural and artificial agents, defining the new Subjectile rather than ultimately optimizing artificial agents to forge the natural emotional disturbance. Besides this, it is, indeed, impossible and may not anyway be necessary to replicate a form of natural consciousness by artificial agents, especially when we look at the perspective of Descartes's Cogito[49]. In other words, it is to consider the 'other'; as the speculative agent other than the self that should be considered in the justification of science and truth (Lacan, 1998a; 2006a), whether it would be the cyborg, humanoid robotics, or a system in the information age, as a 'networked agent'. Observing the perpetual continuum and dependence among those correlations by affecting the self and the belief pattern also establishes the research domain with which the human sciences would deal. Further interpretations would hence be on the technique towards the standard topology of triple (or more) relations of the subject, nature (the other subject, or nature itself, the environment), and the artificial (information, technology).

From Affect and Consciousness to the question of the knowledge of the 'Universe', a

[48] See also (Sennett, 1994).

[49] Cogito: is the self, consciousness, and knowing as being according to Descartes (Descartes, 2008). Hence, Descartes's Cogito corresponds to the recognition of the self by the agent itself as a mode of consciousness. Jacques Lacan considers Descartes's Cogito with his theory of 'the mirror stage of the subject' to identify the self as a conscious state. See also the chapter "Science and Truth", Op.cit, (Lacan, 2006a, pp. 721-745). See also (Žižek, S., 1998; 2007a; 2007b).

similar discussion is also considered in the documentary television program, *Star Talk,* hosted by Neil deGrasse Tyson[50]. In the show, the future of artificial intelligence has been discussed considering the decision making and the argumentation of what if artificial agents such as humanoid robots, Sophia, could have consciousness and free will. David Eagleman, the adjunct professor of psychiatry and behavioral sciences from Stanford University in the program, indicates an entirely different point of view. Artificial agents' consciousness is directly related to what the real analogy to the artificial agents could be. So, what the artificial agents inherently can 'measure' is distinct from what we sense and evaluate the 'other' agents and the external world with respect to our consciousness. The arguments, then, come to the point that it makes sense when we understand the reality of the artificial agents by using their capabilities to measure magnetic fields, location tracking used in GPS systems, gyroscopic assessment, or computerizing the data stream on the Internet and in social media[51]. It would only be possible to make solid inference if we are talking about consciousness and its form of appearance as if it can solely be related to its corresponding 'order of substantial material form' and its accompanying information/knowledge. Whether it is natural or not (as the artificial agent), when we talk about some rational behavior and the form of intelligence, the conscious act can only be possible with the corresponding substantial form of matter inherited from its nature of things. In other words, we are inherited from DNA structures, and it is only meaningful when we talk about consciousness as the sensory awareness recognized by that body of natural formation (Goswami, 1997). It becomes much more meaningful, then, when artificial agents have substantial capabilities to intuit the flowing 'electronically' sensible information as knowledge. It would be profound to question, then, how we should look further for the consciousness of the artificial agents that are inherent with their nature, concerning how the nature of existence emerges and appears for them. The reality of the environment with physical forces and dynamics is also crucial to evaluating the paradoxical relativity of measuring consciousness and yet considering the system of life with perpetually interacting agents and forces.

From computation to Affective Environments: The recognition of human agents'

[50] "Westworld and the Future of AI" Star Talk. National Geographic. 10.09.2019. Television.
[51] even to be recruited as a part of the Internet of Things and as sensorial infrastructures. The discussion is transmitted from Eagleman's talk on 10.09.2019 in StarTalk.

emotional states beyond human-computer interaction is an advanced concern that there are few environmental design cases. Roy Ascott's pioneering work, *Telematic Embrace,* has already uncovered the evolutionary transformation of artworks focusing on the role of artificial machinery in creative production and in the inquiry of consciousness. The theme, 'from Cybernetics to Telematics', does sign for the arrival of the age of Industry 4.0 with the inquiry of possible human-computer interactions (Ascott, 2000; 2003; 2006). Such projects signify agents' responsive actions with various interaction possibilities in more complicated built environments. The designed art environment *The Weather Project*, by the artist Olafur Eliasson (Shanken, E.A., 2009; 2012), is one of the most significant examples. The project integrates the thermodynamic, visual, tactile, and other psychological and even social and emotional states of people visiting the exhibition area that is designed at *Tate Modern* (Figure 2.7).

Figure 2.7. The Weather Project, by Olafur Eliasson, 2003 (Photographs are edited by the author. Courtesy of Olafur Eliasson, https://olafureliasson.net/archive/artwork/WEK101003/the-weather-project), (Left); The Blur Building, by Diller & Scofidio, 2002, (Right)

On the architectural scale, Diller & Scofidio have designed a much more condensed sensorial and programmatically more complex setting as an artificial system of thermodynamics: *The Blur Building* in 2002 for *the Swiss Expo*. Technology of man-machine interfaces, communication networks, and how computing introduces temporalities into the architecture itself via embedded computation and changing programmatic conditions show themselves off in the design (Figure 2.7). The project combines informational and environmental technologies, meteorological systems, a wearable computing system/apparatus, and environmental performance and effects for a different architecture. The aim is to discover other forms of architecture of the random actions through interactive environments regarding robotic technologies and the pneumatic studio for architecture/landscape firms, expanding the scope of temporal architecture, including ecological and environmental systems (Perry, 2013).

In such projects, we must assume that there is no inherent rupture between human embodiment and technical mediation to forge the contact with the domain of information, where digitization works with sensibilities by catalyzing the production of affect by the interface (Perry, 2013). Hence, the spatiotemporal experimentation of Affect can be defined as a pre-semantic topography of sensations as psychic energy. This substantial form of experience emotionally binds people to the earth. It gives way to understand communication and practices in the information age, looking up for the surplus of affect as the investment of energy anchoring people in particular practices, identities, and meanings (Bressani, 2013) by emotional associations.

It is seminal to introduce the original contribution of Michael Arbib to the field of architecture by his novel inquiries on 'Neuromorphic architecture' throughout the analysis of the '*ADA*' Project (Figure 2.8). Regarding the potentials of embedded intelligence of architecture by the sense-based environmental inputs in the field of 'neuroscience' other than the syntactical inquiries of artificial intelligence, Arbib explores the potentials of the neuromorphic computation in his seminal essay "*Brains, machines and buildings: towards a neuromorphic architecture*" (Arbib, 2012). The project follows the inputs and reactions for the five senses of recognition and cognition of the subjectivities with the emotional reflections as a social (swarming) project embedded in the learning environments.

In that regard, it is also crucial to evaluate the rise of neuromorphic computing chips concerning architectural environments, even considering the emotional aspects as well as the utility factors and the monitored behavioral and perceptual interaction of the people with the environment. Departing from the seminal research on Affective Computing, the current inquiries into the rise of human-computer interaction and the role of subjectivity as well as Subjectile other than the blind logic of classical computation and classical means for artificial intelligence, can be best augmented by regarding the new roles of neuromorphic computing chips.

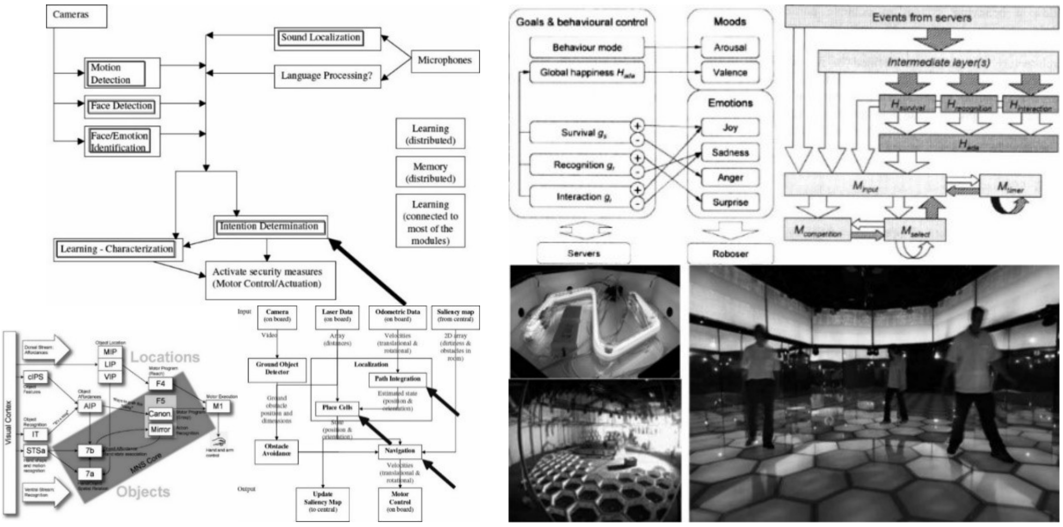

Figure 2.8. ADA Project, 2002 (Arbib, 2012)

Through the *ADA* project, as realized in 2002 for the Swiss National Exhibition (Figure 2.8), it is possible to follow the design considerations of rooms, buildings, and landscapes (Arbib, 2012) in correlation with the sense-based embedded computation elements in the architectonical dynamics. The functional usages and detailing for each neural network layer in the *ADA* project, for processing the different emotional and sensorial inputs and interactive patterns to generate responsive and playful atmospheres with the visitors, give one of the pioneering examples of the learning environments of architecture. Arbib discovers both connectionist and hierarchical models and the mirror neurons' role (Arbib, 2012) to correlate resonating action/reaction chains and associated events as a proxy of neurons commuting between the virtual and actual recognition processes. The layered project associates the models (the layers) and interactions regarding the processing data of sensorial mechanisms to have flexible responsivity by mimicking the randomness of the brain's natural behavior with the potentials of neuromorphic connectionist models.

Similar research projects have become a part of crowdsourcing by the usage of Mobile Phone Applications (iPhone and Android Apps) and other connected and wearable devices of the learning environments (Arbib, 2012). There have also been more complex projects and research regarding the urban scale that have made attempts to integrate the urban settlers' emotional states with architectonic and urban scale dynamics, as in *D-Tower.* The D-Tower project was designed by Lars Spuybroek and his design team NOX (Figure 2.9) (Spuybroek, 2004; Kolarevic, 2005). The project represents the amalgam of behavior where simultaneity and superposition are sovereign. In *D-Tower*, the designers aimed to reveal the Doetinchem settlers' emotional states in the Netherlands each day via the internet questionnaire, 'How are you today?', to be revealed as the dominant color of the sculptural tower changing according to the votes (Kolarevic, 2005).

Figure 2.9. *D-Tower* by NOX (Spuybroek, 2004)

In one of the most inspirational studies departing from the Situationist International project of the *Naked City*, Christian Nold studied *East Paris Emotion Map* in 2008 (Picon, 2015) as one of the fascinating experimental studies in this scope (Figure 2.10).

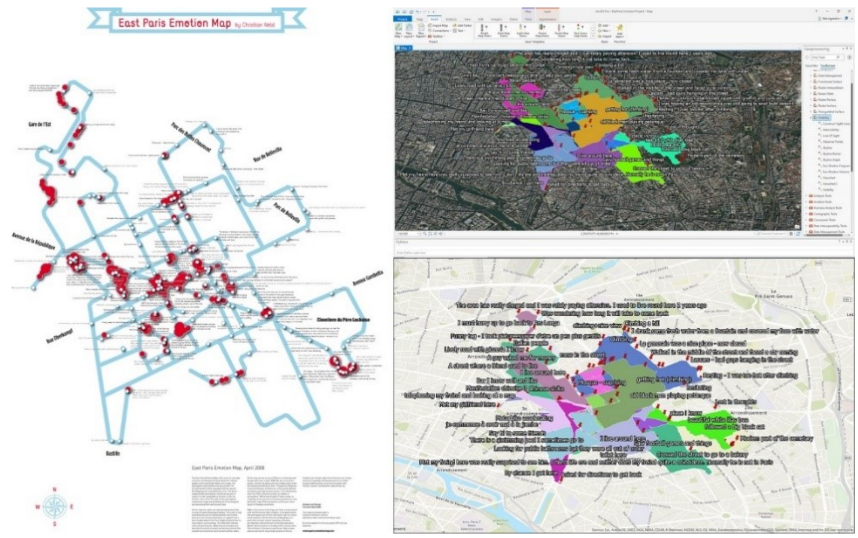

Figure 2.10. Christian Nold's East Paris Emotion Map, 2008 (Picon, 2015). Maps are accessed on ArcGIS Pro having Christian Nold's mapping data from http://www.paris.emotionmap.net/info.htm

In *East Paris Emotion Map*, Nold attempts to map the experiences of eighteen local people worldwide that give data and feedback for the spatial action and the distribution of events and emotional association through East Paris streets and spaces. Such projects ought to be seen as the creative deterritorialization of affect as part of virtualization in the information age, revealing the power of urban space.

In the decision making about the scale of the globalizing architectural spaces, the ornament also emerges as a suppressed unconscious informational pattern at the tectonic scale yet is extended through the whole edifice. Picon evaluates the emergence of ornament in the paradigm of digital culture as intricate. He relates this to culture-based Affective reflections and as a mode of unconscious form retrieval in design and production in the rise of neo-capitalism[52]. It reveals the abyss between the two scales: on the larger scale, the capital's desire of production flow 'mastering' over the larger spaces has blurred the distinction between the infrastructure and a building (Picon, 2010; 2013b). At a smaller scale, conversely, the drive to satisfy the idiosyncratic and repressed cultural symbolisms and semiotic patterns is regenerated with the help of the virtual media, which revitalizes new form-based emergences. It makes the human scale and the modern culture of human-environment interactions go off. The structure connecting the two extreme scales seems to have been replaced with the continuum of ornamental computer-generated graphics that are controlled by information and its networks. Hence, ornament shows not only the political power depicting rank and prestige that is dictated on the tectonics but also the self that is placed among the order of the society with hierarchical cultural and symbolic meanings (Picon, 2013b; 2020; Bell & Zacka, 2020). Ornament, on the other hand, can also be evaluated as a means of communication and knowledge (of making) in production that sets architecture as a discipline, and as the basis for the appreciation of beauty and pleasure (Picon, 2013a; 2013b; Picon, 2014b; 2020).

When to be understood with the meaning of affect, ornament not only communicates through 'materiality' but also as a legitimized authorship of that experience (Picon, 2013b). As a mode of experience, materiality can only become meaningful when

[52] The suppressed desire for the ornamental detail as a drive of the subject that condensed as the sublime deliberations reveals itself as a trace of cultural history perpetually, which should not be repressed any more or not to be over-rationalized to prevent such an aversion, according to Picon (Picon, 2013b).

subjective faculties and the degree of consciousness have interfered with subjective decision making via informational means. This redefines what Subjectile may mean through new generations of technology[53]. The level of consciousness in this experimentality, then, entitles the designer as the executor of the thought and the experience of the produced object[54] with regard to the new technological interfaces of Subjectile of human-technology interactions. When the things are to be seen in the unity of Life that predicates over the 'creative evolution', each aspect of such cultural/emotional disturbance makes us better understand the degree of complexity and creativity of design and Subjectile in evolutionary progress. It suggests a new mindset that should promote the balance among the different action-based dynamics of performance, creativity, and Affect as discrete entities of intelligence in their continuum.

2.4. The Formation of Creative Intelligence in Architecture

In its social formation, agencies' creative acts in social dynamics ought to be considered in their self-autonomous and collective act with certain goals in the rules and procedures of interaction beyond the linear, yet with collective clusters with different consequences (Appendix A). Overall, this concept, in this thesis, ought to be regarded as a form of technological, cognitive, and even social intelligence in their continuum and consolidations among discrete formations, correlations, and forms of collectivities.

In *Affective Computing*, Picard defends the idea that emotion is as influential as performative actions to be considered for the intelligence of individuals that artificial agents attempt to forge. Picard is concerned about developing a solid way of constructing 'intelligence' by regarding emotion and primarily affect, describing the long-term emotionally associated rational behavioral pattern, whereas classical means of computation have no sense of it (Picard, 1997; 2000). By defining the intelligence of the built environment through the togetherness of the subject's perceptual and cognitive dynamics with the innovative endeavor of architectural technology, architecture gains

[53] As Deamer finds the relationship between the detail of craft and the tectonics of space and culture similar to the discussion of 'ornament' by regarding socio-aesthetic issues in craftsman's expression and in the identity of the product, the aspects of Affect in the creation and production, accordingly, represent the transition between the mode of the unconscious and consciousness (Deamer, 2010a; 2010b, pp. 80-89).
[54] See also (Ascott, 2000).

legitimate grounds to discuss ‘intelligence’ as a shared key concept. The search for the common concept of intelligence with reference to artificial logic of computation also refers to a consolidating theme at the organizational level to have collective forms preventing possible refragmentations and further segregations, atomization, and divided tasks/roles in the future of architecture.

Neuromorphic computers have a consequential place in the question of intelligence in the assessment of performativity and energy-related patterns of architectural technologies regarding affect, consciousness, and even social behaviors ranging from artificial intelligence to natural computing and parallel computing mimicking the parallel facilitations of the brain. Zak provides solid grounds through which to evaluate the performative and emotional aspects of agents that are artificial – or otherwise – with respect to the assumption of networked ecologies of intelligence (Zak, 2011). Zak criticizes the linear models that classical neural networks developed. Instead, he refers to exploring non-linear dynamics and chaotic systems’ exponentially increasing complexity (Zak, 2011). This complexity needs to discover the emergence of the new logic behind the revolutionary technology of neuromorphic computer chips mimicking the facilitation of inputs through the human brain and its plasticity by threshold and plasticity mechanisms (Zak, 2011). By reading what Zak attempts to conclude in his critical remarks on the non-linearity and the complexity theories, the study surveys to understand the behavioral pattern of subjectivity and especially intelligence discretely (Zak, 2011, p. 191).

Evaluating intelligence and creativity by the branches of mimicking artificial intelligence does not seem easy, however, without considering Newtonian mechanics with non-Newtonian approaches and with thermodynamic rules (Zak, 2011). Novel intricacies of these scientific investigations are somehow explained through ‘Maxwell’s (sorting) demon’, which relates to the chaos and complexity of matter and entropy (Nielsen & Chuang, 2010; Zak, 2011). This complexity lies in distinguishing the human being with its manipulative capability of having ‘negentropy’[55] that differs from the classical principles for artificial agents. The new neuromorphic chips’ approximating models can be developed according to the evolutionary dynamics and

[55] Negentropy is basically the phenomena of having negative entropy. See also (Song, 2013).

negentropy by manipulating the energy levels when processing information via attention and learning mechanisms. This potential can be seen as the initial introduction to the bright future of Industry 5.0 and further developments.

On the other hand, such projects ought to be recruited for certain social scenarios and environmental conditions, whereas this increases the degree of complexity to its maximum[56]. Zak provides the recipe for how the networked organization of a socio-technological and creative game among the agents (regarding human-computer interaction) can be principally conceptualized with possibilities, uncertainties, and 'natural' random actions by energy-functions and algorithms (Zak, 2011, pp. 227-228). In other words, creativity should be included as playing a pivotal role in such a social game of 'intelligence' that cannot be predetermined, and should be open to naturally random actions and probabilities. These ideas can also be familiarized with what Bruno Latour tries to define individuals' molar togetherness to be assembled as a collaborative network. What is crucial here is to acquire new principles with regard to new social scenarios, especially when neuromorphic computers become more robust and sophisticated, and, indeed, even become social agents of computing. The condition can also be seen as defining the way of how a (scientific/or observation-based) reference system among the agents can be established. In such a case, the complexity of emotional states and their togetherness with the 'collective mind' can be assumed to model the 'conscience of humanized technology'. This modeling can also iterate creative acts as well as the principles of justified decision-making opportunities and justice among the randomized events and agents. The concept of conscience in the theoretical reference system of judgment is fundamental to signifying the importance of assuaging the external monitoring mechanism that entails capitalist competitiveness.

The problem of surveillance of the professional agent to construct the exact representation of the environmental agency and its power should also be re-evaluated

[56] One answer to the problem of the exponential increase of complexity of solution space, thus, can be the practical affirmation of the skillset of creativity in the emergence of new technologies. Nevertheless, this challenge would further be assayed through the advanced concepts of technology and science to be registered under the inquiry of epistemological evolution. When looking from a biological perspective, creativity corresponds to a moment of fertility, a new generation as in the case of execution and that of the described selection of new genetic codes. Arguably, the physical potentials of creativity have much more potentials of that thought as well. As part of the coherent system in life, creativity can be considered a 'manipulated' and yet internally coherent moment of action regarding negentropy. It may even require external forces for the change like 'Maxwell's demon' even if it is regarded against/according to the second law of thermodynamics and the other rules (Zak, 2011, p.170).

under the conception of intelligence. For example, tasks that require relentless monitoring can be taken over by the artificial agents without any modes and interference of affect, emotional, or social disturbance. Such reference systems also consider economic mechanisms, market dynamics, and informational bases to justify ground truth and the ‘logical/cognitive belief system’ to conduct the performative activities and the intelligent correlations among multiple agencies.

The search for humanized intelligence (Fromm, 1968) can be hypothesized with the human-technology interaction and subject-object togetherness from a profound understanding of inspiration with the essence of nature and space-time conceptions. The described correlation is bounded with human-environment interactions and can further be developed again under questioning the advanced space-time concepts. Bergson investigates the absolute space-time concepts to understand the role of creativity in the thought of infinity of space-time and in evaluating sensuality with emotional intelligence and the modes of judgment such as conscience (Bergson, 2002). Creativity and conscience, then, can be (re)generated as another set within and beyond the scope of intelligence in the evolutionary dynamics of discrete (or infinite) space-time (Bergson, 1998; 2002). The described mindsets constitute the operational dynamics of the centuries-old faculties and domains as ensembles in different ratios.

Some of the interesting arrays, consecutively, can put the imagination and perception in train under the same performance domain by human-artificial cooperation. Then, the assessment of performance can proceed with the necessity of assessing ‘Affect’ to come up with a humanized form of intelligence in sensual space-time. This set lines up in a relatively circular logic that can repeat itself in the progress of monotonous growth. Yet, it is also possible to consider the concept of discrete coexistence of subject and the artificial agents as tried to be described as correlated ‘Digital Twins’. The aspects of creativity and conscience beyond sensual intelligence can also be assigned as the core complex programmatic steps in the ‘logical belief system’. This set defines the modes of ‘creative evolution’ for another extended (vicious) circular behavioral pattern (Bergson, 1998, pp. 186-272) as a hypothetical program for human-computer interaction.

On the other hand, generic program proposals for new human-artificial interactions can be evaluated for different conceptual mindsets to interpolate subjects in the informational transformation. Such logical programs may return an evolved mode of performance by the discreteness of creativity in later moments/epochs. The assessment of conscience, as a continuum of such a discrete form of lineage, referring to the existence of judgment reference system, in that sense, corresponds to higher degrees of space-time conceptions such as the justice of action (Bergson, 2002) in the forms of evolutionary intelligence. The biased (ideological) and desired versions of the relative mindsets would also affect some of those circular and linear patterns to achieve a certain level of decision-making.

2.4.1. From the Cognitive Aspects of Intelligence to the Intelligent Environments, Smart Spaces, Smart Cities and Digital Ecologies

In this research, intelligence emerges as a unified operational domain of formal and artificial logical sets and abstract relations of subjectivity for further interaction through informational revolution and architectural innovation. The parameters of discrete modes of creativity also exist outside the borders of sensual intelligence. Intelligence that is to be defined within and beyond the borders of sensuality includes the abstract concepts of experience as well as the formal kernels of space-time, and indicates the identities and flow of energies that are filling in. Space-time evolution (Akhundov, 1986) and the role of perception of an individual in/through, hence end up with a discussion of intelligence (Bergson, 1998) together with the manifolds of spatiotemporality that are concomitant with the aesthetic (space-time) conceptions. Intelligence is to be regarded with material and cognitive performance as well as the embedded 'Affect' of emotional associations. They range from the cognitive, tectonic, and material aspects to the organization of environments and common platforms of 'decision-making' mechanisms, and socially, naturally, and technologically sustainable experiences of intelligent/urban environments.

In the review of architecture, the concept of intelligence has an overarching impact on the definition of common grounds between the peculiarities of creativity and innovation of architectural technologies. Nevertheless, the concept of intelligence, looking from such a perspective, is not even new. Intelligence in architecture involving human-computer interaction dates to Nicholas Negroponte's article in *Architectural Design* magazine, *Towards a Humanism through Machines* in 1969 (Negroponte, 1969a; 1969b; Menges & Ahlquist, 2011) after the concept of humanized technology

(Fromm, 1968). The most significant and most impactful resources can also be found in his studies at the MIT Architecture Machine Group in the late 1960s. His book, *The Architecture Machine* (1970) and another article, *Reflections on Computer Aids to Design and Architecture* (Negroponte, 1975), have similar programmatic missions.

It can be said that Negroponte's seminal book (1970) for rationalizing human-computer interaction gave way to Mitchell's initial endeavors on CAD logic (Mitchell, 1977). Mitchell's book occupies the place of what we can regard as the milieu for the development of CAD logic (Mitchell, 1977) and BIM technologies today. With the second title, *Toward a More Human Environment*, Negroponte's book in 1970 can also be seen as the pedigree of inspirational studies like Mitchell's *The Logic of Architecture* (1989, 1994). It briefly describes the associative bases for how the robotics of human-computer interaction and artificial intelligence could be imagined by considering the paradigms of decision making, game theory, economics, and psychology throughout the 1960s and 1970s. Similarly, Mitchell's work aims to put forth the descriptive logic of computation for how design elements and properties can be constructed and parametrized. Such a design approach was also further developed, without the theatrical presence of interaction with the robotic interface, by Ömer Akın in *Psychology of Architectural Design* (1986) and, later, in his book on 'design rationality', exploring the principles of artificial intelligence[57]. The book consists of the directed commands and iterations of the user, rationally based on Newell & Simon's studies, and can be seen as constructive to implement space syntax rules in artificial intelligence. Such studies have given the fledgling grounds of simulative 'electronic twins' and smart environments for urban computing (Mitchell, 2003b).

As the founder of MIT MediaLab, Negroponte, with his futuristic endeavor in *The Architecture Machine*, establishes the grounds of artificial intelligence for architecture towards Industry 4.0. Even the attempts of simulative spaces such as *the House_n Research* and further *The PlaceLab* examples at MIT (Figure 2.11) (Larson, 2010) are

[57] Looking over the relation of architecture with science and especially the sciences of the artificial agents inspiring from Simon's seminal book (Simon, 1996), Akın explores the data structures and their processing similar to the artificial brain of computation with short and long-term memories to reveal how the logical iterations can be hierarchically modulated as data structures (Akın, 1986). It is possible, then, to evaluate this phenomenon together with the design of receptors and effectors in connection with the environment throughout processors; and their application through the heuristics methods in artificial intelligence by the breadth-first and depth-first searches in the endeavor of architecture focusing on the sciences of decision-making and architecture (Akın, 2006).

based upon Negroponte's arguments and Mitchell's descriptive computational logic. They can be seen as the substantialization of realistic, intelligent environments. The generation of intelligent and learning environments also evokes the new role of the neuromorphic computing chips once again with the help of embedded computation, microcontrollers, and new means of artificial intelligence concerning the development of smart spaces and even smart grids.

On the other hand, there are significant arguments regarding the competing paradigms of non-linear dynamics based on the intricate cases leading to the discussion of the impossibility of certainty in decision making (Picon, 2010). The idea even challenges the determined togetherness of human-computer interaction and the linear logic of computation, as Kwinter discusses in *The Computational Fallacy* (2002) (Kwinter, 2011), which is elaborated upon in the following chapter. The overarching agenda of intelligence should pursue the matter as not only informational data but also social and environmental facts by the topological togetherness of nature, society, and technology with the parameters and effects of cognitive recognition and design. In that regard, material intelligence is argued to be the substantialization process of things with their form, material qualities, and energies together as a coherent order. In technological advancement, material intelligence may encounter further challenges of intricate non-linear order and complex material formations (Menges & Ahlquist, 2011).

The intelligence of material behavior (Carpenter, 2010; Najle, 2013) is used to produce new forms of architectural order and coherent structural systems. In recent years, Achim Menges and his design lab have shown remarkable progress in their many successful realizations. The relation of the digital design with computation has transformed towards searching for the behavioral balance between structural stability and functional capacity and flexibility (Baudy, Koehl, Menges, Reichert, 2015). This progress is to be regarded in design as performative parameters that are diverted from the idealization of geometry and form. This should be considered with a design logic, so it should be taken as a form of intelligence. The substantialization between matter and form makes use of a better conceptual understanding of the progress of intelligence. Cultural significance and performative aptitude are significant when departing from the materiality of intelligence that architecture should consider.

On the side of the production from material to virtual interfaces of generic objects as subsequent agents, networks, as well as texts, images (or other types of manifolds of sensuality) of design activity (Courchesne, 2013), Objectile is very efficient at defining the atomically precise manufactured object of production and consumption (Drexler, 2013; Carpo, 2013b; Carpo, 2014). It is the condensed form of information that appears as the form of the materiality of experience, and shows intellectual and mental processes of perpetually repeating creation[58]. Kolarevic similarly explains Objectile as intelligent objects of Industry 4.0 as an overarching procedure through design and production (Kolarevic, 2000). It is possible to regard the recent advancements in the nanostructures of organic chemistry and the adjunct nanotechnological self-assembly technologies ranging from graphene to polymers[59] (Figure 2.12), polypeptides, and other folded macromolecules (Drexler, 2013) to catch up manufacturing and other technological capabilities. Respectively, the additive manufacturing (Sorguç, Özgenel, Kruşa Yemişçioğlu, 2018) and fabrication techniques, by augmenting the current abilities and volatile action of 3D and even 4D printing (Correa Zuluaga et al., 2020), can be claimed to be other advanced methods of manufacturing that utilize novel materials.

From material intelligence to the rising paradigm of 'embedded intelligence' forging for the self-sufficient behavior of materiality of architectonic elements, the corresponding reality in architecture covers the factors of the user, material, or technology. This phenomenon also claims for the participatory, social, and environmental concerns expanding the boundaries of the interest and the definition of intelligence. The rising connectedness of the virtual interfaces between the material and design does augment the cognitive boundaries of this definition of intelligence. As the designer can also be the self-editor of Objectile, and since every consumer can generate data as well, an aggregate of collective data can be achieved via a 'participatory' process through open-source software like the Internet of 'Architectural' Things and Archipedia (Carpo, 2013a; Beyea, W., Geith, C., &

[58] See also (Deleuze, 2006; Speck, Knippers & Speck, 2015).
[59] Menges and his team explain the innovative structural endeavor in their ICD/ITKE Pavilion that is made from coreless-wound-fiber-reinforced polymers constructed in 2016-2017 by the seminal search of the structural cantilever through the strength of lattice structures in nanoscale production (Solly et al., 2018). See also (Menges, 2013; 2015a; 2015b; Menges & Knippers, 2015; Schwinn, Menges, 2015).

McKeown, C., 2009). This idea can lead the social communities of new media into the voluntary members generating instant and ubiquitous updates in the permanent duration of evolution and variations. Less predictable boundaries of this domain imply true randomness of the collective knowledge of society (Carpo, 2013a).

In the intellectual dimension of collaborative and cognitive act of design, Carpo draws the outline for the modern authorship of architect-scripters having an alliance among technology, complexity, indeterminacy, and mysterious capacity in the self-organization of natural and social systems (Carpo, 2013a; Snooks, 2013). A major problem, then, appears in reauthorization, redetermination of the already identified under the constrained sets of virtual parametrizations or representations. Nevertheless, genuine sharing environments of collaborative design, even for the versions of BIM software, apply for the natural selection or the instant emergence of form with the help of the randomness of 'crowdsourcing'. This collaborative environment may suggest a creative method with the rise of artificial intelligence and the Internet of Things. Hence, the Internet of Things can be seen as extensively novel means other than the traditionally accustomed practice for social participation throughout virtual partnerships/contracts.

Thus, intelligence can be seen as a heroic turn in the creative act of the agent among the individual performances and social culture in the activity of design, embodying the novel formalisms and operations of swarm systems, generating collective intelligence. The quantized form of conception among the discrete and rational mode of separable and non-separable acts and entities of design and the collective formalisms of *Objectile* can come together in the empirical boundaries of such an intelligence.

The role of intelligent environments also signifies spatiotemporal participation and creative actions. Considering the interactive dimensions of decision-making in space, smart house and automation systems' rising impact and the extensive research on smart grids are of paramount importance to discuss here. The initial sign for the intelligent environments, hence, also dates back to the futuristic projects of the 1960s, such as Archigram's *Computer City* (1964). Cedric Price's inspiring simulative environment of *Fun Palace* has also led to the computer-simulated environmental prototype of Price's *Generator Project* in 1976 (Picon, 2010). *House_n Research Consortium*

(Figure 2.11) project, accordingly, is an outstanding and pioneering example to discuss this progress that is realized at MIT Media Lab (Larson, 2010). The realistic environment with simulative/virtual generations and certain materiality of physical interfaces uses an interactive table and other web-based interfaces to realize the spatial configuration for the other actors and environmental forces generating intelligent interaction and crowdsourcing environments (Figure 2.11).

House_n Research Consortium's apartment-scale counterpart is decorated with the smart infrastructure of solar systems, HVAC control, lighting by considering aspects of comfort, sanity in *Urban–infill condominium* and in *The PlaceLab* (Figure 2.11). The projects make the façade components respond to environmental context (Larson, 2010). In the projects, Kent Larson provisions "self-configuring, self-maintaining, easily adaptable, and expandable infrastructures" while he claims that with the help of more straightforward sensorial data creating learning environments, there would not be necessarily complex computation (Larson, 2010). Increasing the demographic, health, and energy challenges of society promotes architects to play more substantial roles in the manipulation and control of those factors by reinventing the design and fabrication processes according to novelties. The increase in the smart houses/apartments/infrastructures reveals the need to deal with Big Data and the networked relation of those systems under the environmental effect and interactions.

Figure 2.11. House_n Research Consortium (left); Urban infill condominium (right) (Larson, 2010)

It is also possible to evaluate the place of smart grids concerning public and private usages. The energy usage, environmental and behavioral patterns acquired by smart grids, and connected devices in the built environment can augment crowdsourcing possibilities for smart cities and urban computing. Consideration of the occupancy factor to its fullest extent needs to deal with the crowdsourcing by the IoT and Big Data of preferences and informational data of things. Exploiting the potentials of AI and genetic algorithms by processing images and data from the user and environment, such projects can also claim the collaboration with the other agents on certain networked platforms. This can be achieved by communicating through each construction element's object-based information with the help of Building Information Modelling and similar software in the corresponding algorithms and crowdsourcing methods of artificial neural networks. Therefore, the future of BIM technologies integrated with crowdsourcing technologies and via the Internet of Things (Dave et al., 2018; Li et al., 2018) can be claimed to be the future of such technologies.

The change in nanotechnology and new manufacturing techniques becomes crucial to envision the new aspects of software development. Projects like Autodesk Cyborg (Figure 2.12) try to simulate the 'DNA code-like information' of those materials interacting with the environment. The Internet of Productions, as a proposal, then, can enable them to consider the higher dimensionality in 4D printing by the numerical formalisms of the lattice structures of nanoscale materials. The time-related parameters of resonance in the quantum fields would be seen as further additional dimensions for the instant production or substantialization of things. Such claims should follow topological Objectile-Subjectile togetherness as strong human-artificial correlations towards generating higher-dimensional data as topological entities' parameters.

This discussion foretells the necessities of the architect's conscious decision making and the concern of architecture as a culture, discipline, or profession regarding its creative agents. After the gentle introduction to the concepts of intelligence in architecture, the discussion can be integrated with later discussions of creative and collaborative models for the workflow within BIM technology and even at the 'Infrastructure Design' by IoT projects. The discussion of consciousness and social aspects, on the other hand, leads to certain complexities and uncertainties, and it becomes hard to determine appropriate rational and straightforward means. Accordingly, the discussion regarding non-linear and differential evolutionary logic will be extensively explored in the next chapter.

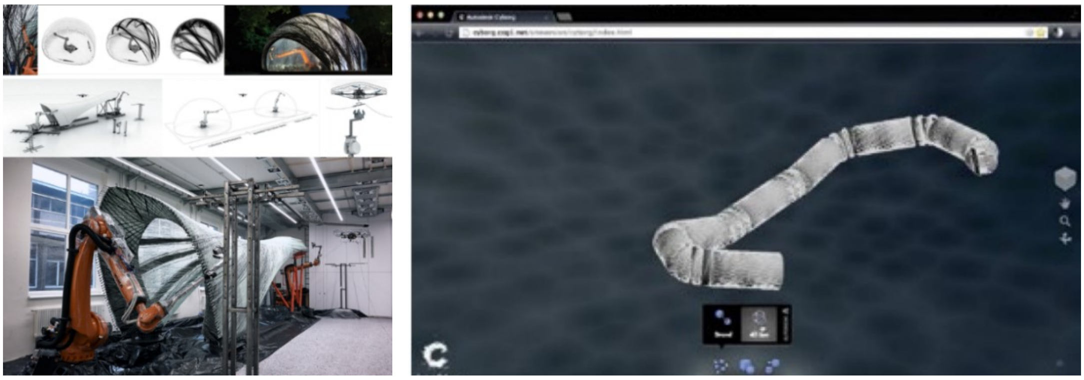

Figure 2.12. ICD/ITKE Pavilion (above left); Construction of ICD/ITKE Pavilion 2016-2017 by the (below left); Autodesk Cyborg project developed together with MIT MediaLab as an interface for 4D printing simulation (Tibbits, 2014) (right)

The role of rational decision making and collaboration in architecture is not actually new[60]. Nevertheless, the condition of workflow in the professional environments of larger-scale projects and accompanying studios today correspond to far more complex scale problems, even in the most rationalized linear processes[61]. Therefore, means of communication through nature, artificial, and the subject's mindset have gained priority, integrating the design processes with protocols in professional environments regarding the creativity within (Tombesi, 2010). While including most of the rationalized aspects in professional environments, the main parameter should be denoted as labor, with its mental and physical efforts.

Connecting the interrelationships and flows of relations in design from project to product by advancing technology and reorganizing production protocols with multiple agents necessitates the functional interdependencies on different sides as the engineer, fabricator, constructors, managers, and technical consultants. However, the strong correlation of those functional dependencies can make the re-composition of labor/tasks harder, which may cost a lot. In this process, the modulation of tasks can decrease the interdependencies, and the separation of architectural labor can be efficient when the organizational economy is considered. The more complicated

[60] Moreover, it can be exemplified by the rational iterations of Nicholas Negroponte, William Mitchell, or Ömer Akın for deciding on the spatial elements and their logical arguments, for instance, in the book "Psychology of Architectural Design" (1986). On a larger scale, it is possible to standardize some implementations as points of view with the help of Christopher Alexander's ideas from A Pattern Language (1977).
[61] See also (Bernstein, 2010a; 2010b). Bernstein shares the workflow of one of the largest architectural design companies in the world, SOM, to show the linear process having many subroutines.

factors, increasing with the scale of design, are to be considered prominently.

Contrariwise, it is possible to argue that the design process has an intrinsic nature that should not be divided into modular parts, as this can prevent the potentials of creative action. In that regard, creativity in constraints also necessitates governing series of rules/protocols among the determined modules to find unity. The synergy by the abilities in getting/providing information, interacting, and collaborating generates the surplus of knowledge and efficiency, makes accurate decisions, and predicts future of environmental, ecological, and economic sustainability. Thus, intelligence should be seen as the solution/probable phase space (as a corporate action capability of faculties, agencies, interfaces, and infrastructures) to explore ideas, possibilities, ways of interactions, potentials and limits, and future estimations.

The rising transdisciplinarity on the compounded products, accordingly, is one case that should be regarded with the dynamics of multiple actors and their decision-making processes. Such innovative approaches require a networked organization (Taylor, 2010) and the transformation of technology with the perpetual change of the roles of agents. The increasing perceptual data, environmental inputs, missing user considerations, and even online contracts between the parties like contractor considerations should be regarded as the obligatory aspects that can be integrated with the 'artificially intelligent' architectural interfaces and the Internet of Things. The placement of materials, equipment, the coordination of other elements before construction, and many other behavioral roles and factors, can be decided immediately by the first user or decision maker. This can also be performed with the help of necessary interfaces possibly reinforced with the 'embedded neuromorphic computing' in the future. They can generate *Big Data* by crowdsourcing methods for the complex decision-making procedures, which necessitate the internalization of novel approaches of networks to collaborate in share. Common platforms can enable the access of new perceptions regarding learning and intelligent environments, and the knowledge processes through the Internet of Things. When recalling the role of the smart spaces and the connected devices of Industry 4.0 besides AR and VR technologies in the crowdsourcing of Big Data, it is possible to envision the ecology of digitally connected devices and software for architecture. These potentials can perpetually generate useful sensorial, perceptual, and energy-related data about the factors of usage, function, tectonic, and technological elements of the environment and materiality in design and production.

2.5. Concluding Remarks

In the definition of creative evolution in architecture, the role of human-computer interaction and new relations are evaluated in this chapter. Bergson's creative evolution and the idea of creation and genesis is interpreted accordingly with the concept of 'Intelligence' from his book (Bergson, 1998, pp. ix-xv, 137-185, 236-251) in the fertile moment of the creation of information. In that regard, a proposed form of intelligence (Bergson, 1998, pp. 186-271) as a significant 'concept' among the subject, nature, and the artificial is pursued by extending arguments with regard to the cognitive, organizational, spatiotemporal, and epistemological domains discussing the 'content' of evolutionary architecture. The greater power of nature is able to combine the signs of the evolutionary progress of reproduction, adaptation, and growth within the dynamics of life and intelligence, as seminally discussed by Bergson in 'Creative Evolution' (Bergson, 1998). It is believed that the consideration of this creative power of nature can also enable us to imagine the future capacities and capabilities of technologies developed with regard to Life in creative evolution.

Moreover, Bernard Cache's seminal concepts of Subjectile and Objectile are introduced in this chapter to redescribe the dynamics of advanced human-technology interactions and the roles of new-generation computing means, such as neuromorphic chips. The creative act of subject by decision-making, design, and production as other possibilities of Subjectile is also investigated. Regarding the performative capabilities besides the metabolic and distinct individual reactions and affect, such relations may also imply a form of nature that can be described with the key term intelligence once again by referring to Henri Bergson's seminal ideas in his book, *Creative Evolution*.

Architecture reveals the virtual possibilities of the performative capacities to generate the most efficient, intelligent, and even socially creative correlations among artificial and human agents with regard to the changing revolutionary technology. By key concepts of performance, Affect, and intelligence, common mindsets necessitate the inclusion of the evolutionary aspects of technological advancements and creativity. The research also presents creativity as the free emergence of individual intelligence in this theoretical framework. With the degrees of complexity in the direction of growth, creativity, and social behavior, individuals are distinct from the artificial non-living agents even if they have the same action (Zak, 2011). Respectively, this chapter aims to understand the evolutionary directionality of the human and natural agents distinct from the artificial for the peculiar redefinition of Subjectile.

In that regard, the research regards 'the evolving dynamics of innovation at architectural technology as a professional domain' together with the role of creativity and the moment of creation in human-artificial interaction. This inquiry needs to shed light on the analytical projections of the historical materialism and the culture of architecture on the actual of what is lived, and to explore the potentials and limits of science, technology, theory, and production. The upper and lower bounds of these practices and thoughts reveal the picture of the 'creative evolution' on the grounds of togetherness of Subjectile-Objectile and the environment. Thus, architecture can be seen as a process of adaptive learning between the epistemological understanding and the practice of human-artificial-natural topology.

As being the sensual manifold between the conceptual way of thought, the conceived, and the material practice of performance in the information age, architecture also unveils potential for the virtual within the limits of the creative thought in human-computer correlation. At this point, it is seen as utterly naïve not to consider the future of technological growth planned by the grand shareholders of the world economy in the direction of sensual richness. Having an ideological consideration against such an economy-political reality disregarding or even ignoring financial and social facts would be the mistake that architecture has made throughout the ages, leading to it remaining a number of steps behind the other disciplines in the growth of scientific and technological developments. If architecture may not take an active position in such developments, once again, it would imply being a passive spectator of technology (Cunningham, 2016). On the other hand, architecture can be ground for new technological growth. The creative act of architect-subject has the sensorially-enriched performative definitions that have the capacities to orient the technological growth.

Further challenges of computation and new generation technologies signify the emergence of an 'infinite game' rather than the predetermined conditions for artificial intelligence. This inquiry includes the artists, architects, designers, and engineers in the game to solve design challenges[62] (Erler, 2019). It is possible to develop forms of organizations and knowledge flow/correlations between the creative act of subject and architectural technology for the new Subjectile reading again the necessity of creativity in correlation and even coexistence with the neuromorphic computation and the collective being with probabilistic computation. In Oxman's considerations on creativity and innovation, creative energy seems to play a vital role in describing the correlation of design and sciences in the 'Age of Entanglement' (Oxman, 2016).

Developing sensorially rich interaction interfaces and environments (Johnson, 2013) can be considered to produce niches for Subjectile for the creative coexistence of the architect-subject and state-of-the-art technologies, especially in the collective processes with the help of the Internet of Things. On the other hand, the task of discriminating cognitive bias, as well as the weaknesses of agencies in those correlations, can be performatively compensated by the artificial agents and by efficient assessment methods[63], models, and constructed modalities and simulations. The different aspects of human and artificial agents will help to design the interfaces with their superior features in correlation. Prediction in life events and the capabilities to manipulate the internal thermodynamics as a Living system are the primary features that make natural agents survive and distinctively creative, adaptive, and intelligent. Immediate detailing with computation and enumerating the number of solutions and possibilities and the consideration of intact details without any risky actions in design and manufacturing seem to be the positive aspects of artificial agents, on the other hand. Such considerations are necessary to correlate distinct agents to overcome the anxious problems of competitiveness and efficiency, which become the constraints for humanity. Respectively, the intelligent and creative togetherness of subject and

[62] Erler founds the connection of the rise of artificial intelligence with the more straightforward development of simulative experiences and interfaces of games (Erler, 2019) in the inquiry of design and science relations.
[63] F-scores for artificial inputs and Z-scores for the general behavior can be provided as scientific assessment techniques in the correlation of different agents, even on the same task as working models to detect discrepancies and increase efficiency and coordination.

artificial agents can overcome greedy but destructive politics without generating further social and economic problems of unemployment. On the other hand, artificial agents still leave the human agent solely unique with regard to his/her singularities of language, creativity, and the nature of reproduction, as well as consciousness in the convolutional task of decision making (Bergson, 1998, pp. 177-185).

Thus, how the architectural subject and its collective organizations would be affected stands as another major question that ought to be analyzed in the redefinition of Subjectile. The collective behavior between the natural and artificial agents can be put in the proposal for Industry 5.0. As a general statement, the rise of state-of-art technologies, new informational and knowledge-based grounds can change the definitions/dynamics among the architect-subjects dealing with advanced informational technologies and generation of knowledge-based resources of performative tasks. This progress could imply the tendency to occupy the central dynamics in the redefinition of cognitive and spatiotemporal intelligence. In that regard, the potentials of new means of production like the future of Objectile such as 4D printing; crowdsourcing, IoT, and Big Data in design; and the rise of the intelligent environments can give rise to new mind and skillsets of the self and collective forms of architectural subjects. Even though it may yet to come and urge to practice more on what can the new Subjectile be from various alternative argumentations, it is clear to tell by which means, methods, and concepts and how Subjectile can be redefined in architecture in the rise of state-of-the-art technologies.

According to this, it can also be argued that on the positive side, the rise of technological possibilities, information-related manufacturing, production relations, and knowledge-based creative productivities can further flourish the new grassroots in the internal dynamics of creative architect-subjects. This formation can also tend to be decentralized or occupying new strategic nodes/roles about novel performative, Affect-related, and organizational tasks. Furthermore, the rise of advanced technologies could risk causing further defragmentations and even a decrease in some of the agents' and collective groups' significant roles if not adapting to the overwhelming efficiencies and competitive grounds by technological advancements. In that regard, the study defines intelligence not only as an overarching cognitive theme over performance and Affect, but also as an organizational form of collectivity that can overcome further fragmentations; for instance, with the help of blurring boundaries between the definition of specific tasks. The definitions by blurring the boundaries among disciplines by the entanglement of design, engineering, art, and technology do help to consolidate those collective organizations and even 'conscious' formations from different professions in a coherent unity.

Nevertheless, to get how architectural subject and its collective forms would be affected by other dynamics outside the architect's direct relation with technology can only be clearly understood with an overarching survey of the evolution of architectural paradigms in relation to socio-economic, cultural dynamics, science, and technology. Respectively, it is also possible to understand the evolutionary trajectories of architecture and how the organizational bases of creative collectivities could be formed by the built environment in transformation with industrial revolutions, architectural mainstreams, and avant-garde movements.

The organization of new creative collectivities should also be defined with the informational knowledge creation and their spatiotemporal repercussions regarding the industrial revolutions and new generation computers. In short, this chapter concludes by reminding of the epistemological 'possibilities' of intelligence in technology/information besides cognitive, spatiotemporal, and organizational aspects. Technological and scientific inquiries enjoin us to consider the world of networks (of super-positions[64]) and the potential growth of technology in the search for imagination and creativity. The inquiry explores the possibility between the actual technological capacities and the virtual design of tectonics and epistemological grounds of futuristic experiences of such 'Intelligence' to generate architecture's autonomous discourse. The belief behind this autonomy is to decide on the new technologies and means of production and on what Subjectile could be. Such growth necessitates the organization of the built environment with the interaction of the natural and artificial agents in unity with an environmental intelligence seeking for the complicated means of (natural) computation[65], indicating possible technological revolutions for architecture.

[64] and super-symmetries as an inquiry of space-time relations.
[65] See also (Tomassini, Antonioni, Daolio & Buesser, 2013).

CHAPTER 3

HISTORICAL RESEARCH OVER THE EVOLUTIONARY RELATIONS BETWEEN SUBJECT, TECHNOLOGY AND THE BUILT ENVIRONMENT

We are living in the age of Industry 4.0, implying the start of the Industry 5.0 revolution. The built environments we settle in cities and metropolitan areas, however, have influenced from the precedent industrial revolutions under the progress of change of intertwined economic, socio-cultural, technological relations merged/fluctuated by these revolutions. Accordingly, this chapter explores the historical background for the togetherness of evolving trajectories of the modern built environment and technology, production/industry relations in architecture.

The recent evolution of creative subjects' position with technology via the redefinition of Subjectile reveals the multiplicity of different reference systems and the future of new organizational forms of creative collectivities. However, they cannot be entirely determined without concerning the built environment and questioning technology and industrial revolutions together. This chapter thus provides a historical background to review the paradigm shifts by technology we use together with the emergent complexities of paradigms of the built environment we inhabit. This research is further believed to enable us to think about abstract modeling for new Objectile-Subjectile relations by regarding the role of the built environment and creativity within the evolutionary movements through decades.

In the age of quantum theories, we cannot assume any agent outside the observation of environmental action[66]. In this chapter, it is again to ground the subjective basis,

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[66] Quantum observations only give probabilistic results in the environment that cannot be measured without considering the condition of the observer. Regarding the topology of the togetherness of human-artificial and natural environments/agent, it is crucial to consider further the challenging issues of action of probability just as in the mysterious uncertainty of 'Schrödinger's cat' (Wichert, 2014) to find out the correlation between the respectively discrete, independent events. Quantum theories claim that the interrelation between cause and effect and the prior and posterior evidence, in that regard, are not as straightforward as the in ones of the classical theories.

first, to discuss the togetherness of the built environment and the growth of technology we use. This relation calls for the human-artificial-natural topology in human-technology-environment relations. The transformation of technological learning environments in Industry 4.0 with science and production also corresponds to the multiplicity of the flow of everything regarding the production relations by Objectile.

The togetherness of the built environment and technology accumulate these different reference systems and the actors/members of those multiplicities, which can only be randomly observed in the restricted linearity (Erzen, 2017). These multiplicities appear in coexistence or shifted oppositions in linear as well as in circular logic of space-time experiences. In other words, the different movements and collective manners in the profession of architecture can be identified as merged into each other without only looking at the form relations. Thus, the research also gives clues about how the built environment is produced through socio-economic and techno-cultural changes. Hence, the third chapter describes the non-linear history (DeLanda, 2000) of the togetherness that we experience in the built environment, especially with the influence of industrial and technological transformations. It is significant to first understand where the topology of human-artificial-natural dwells and in which domains it becomes accessible to our knowledge in the actual condition of the information age with an evolutionary history of science and technology that coexists with these transformational processes.

It is possible to picture these evolutionary multiplicities in two different paradigmatic turns, implying the third with reference to the creative process of humankind and its togetherness with the artificial and cultural references by the inspiration from the first nature[67]. The first turn is about the built environment that we live in and generates the references about the second nature of the architectural subject. On the other hand, the second turn leads to the emergence of the digital culture influenced by science and technology due to the agenda on non-linearity. Thus, the chapter also aims to look at

[67] The emergence of the primary confluence of multiplicities, as a broad introduction to culture-nature dichotomy, can be ascribed first to the psychology of the first nature and second nature (Sargın, 2000a; 2000b). The struggle with the first nature of the humankind can also be accounted for the propulsive force in the explanation of the genealogy of the second nature. The domination of human being over nature, further, corresponds for the satisfaction of needs and desires mostly resulted from the self-explanatory processes of subjectivity (Erişen, 2016b). For the inquiries on the psychology in the process of modernity and the new age please also see (Jarzombek, 2000; 2016).

the evolution of cognitive, spatiotemporal, and organizational formations, besides the relation of epistemological reflections in architecture's evolutionary trajectory concerning industrial revolutions and significant events. Therefore, this part of the study also claims to have a preparatory ground to relate the subject-nature-technology topology in the built environment.

The First Paradigmatic Turn in Architecture's Creative Evolution: Starting from the ideational influences of the first (mechanical) industrial revolution, the subjective interpellation around human-nature-artificial togetherness other than human-computer interaction has profound meanings in philosophical and social terms (Althusser, 1971; 1996; 2008). These initial paradigms' dynamics can be grasped as the oeuvre of the second nature that can still be formed around the first nature, and define the hybridity of the consequence of the challenged imagination within the realities of space-time experiences as required performativity of the subject-object interaction.

Dwelling on the keywords of performance, creativity, Affect, and the industrial revolution, this first turn, respectively, reveals the first and second nature of the built environment. The role of creativity, performativity, and culture through production and technology is focused with greater attention on the evolutionary trajectory of architectural mainstreams and avant-garde movements in continuum besides the discrete and ruptured progresses [68]. Regarding the industrial revolutions, it is consequential to remind the place of modernity and its opponent, postmodernity, and cities' traditions[69], as generating most of the built environment.

From the rise of Modernity to the World Wars, the emergence of information theory, the rise of automation, the events of 1968, and the shift towards the 1980's Just-in-time mode of production have also affected architectural practice, theory, and the built environment. Spatiotemporalities and organizational aspects, then, are analyzed accordingly to consider the epistemological vestiges of architectural knowledge. University environments, for instance, have also been affected by these changes as they have strong relations with society, the built environment, production, and

[68] See also (Hays, 1998a; 1998b; 1998c; 2009).
[69] See also (AlSayyad, 2001; 2004; 2006; 2011; 2014; AlSayyad & Castells, 2002; AlSayyad; Gillem; Moffat, 2017).

technology (Frampton, 1992; Sargın & Savaş, 2016). Thus, universities can be closely scrutinized in the generation of the knowledge and creative subjects of architecture and the dynamics of the built environment. Additionally, academia's autonomy and parallel evolution of research environments concomitant with industrial revolutions and technological growth are also significant issues to be considered accordingly. However, the digital paradigm in architecture, described as the second paradigmatic turn in this research, emerges as different from these reference systems by directly considering the role of technology and the digital bases in a discrete manner. Hence, this approach can be acclaimed as generating the creative evolution that is separated from other trajectories, and generating the uncanny togetherness of the built environment we live in and the technological environments we use.

The Second Paradigmatic Turn in Architecture's Creative Evolution: The non-linear history of architectural evolution by human-nature or subject-environment relations has been further complicated with the rise of new technologies. This needs to be considered with modalities of human-nature-technology relations. This conception will be discussed as the second paradigmatic turn in architecture regarding creative evolution. The corresponding science and accompanying technological transformations from the birth of theories of complexities, non-linearity, and chaos theory have grounded the theoretical basis for this second turn. This epoch is coeval with the complex differential geometries and equations like the emergence of Gödel's theorems and Hilbert's Sixth Problem towards the three-body problem, as well as other scientific research like D'Arcy Thompson's and Poincaré's efforts. The studies by von Neumann have further knotted complexities between humans, artificial, and nature that will be scrutinized in this chapter.

The emergence of non-linear science and systems has also influenced architectural technologies for design and manufacturing. It generates the new paradigm's grounds focusing on the entirely different agenda of mathematics, geometry, and the natural principles in biology and physics. Kolarevic also sees the rise of topological geometries of Lynn's maneuvers from the deconstructivists' logic as manifestational. The paradox between the role of Objectile and the built environment we live in has stratified these relations. Therefore, these relations can be reconstructed through the transference between cognitive senses and the sciences of the artificial. It is crucial, then, to discuss the place of Objectile, Subjectile as well as intelligence and creativity, once again, as the singular theme(s) to bridge the gap between the production and design relations through the built environment, society, and action of things.

The popular and common issues such as parametric design or evolutionary and genetic algorithms in computing and architecture await further analysis through the recent paradigm. This idea acclaims Frazer's (1995), Lynn's (1999) as well as Jencks's (2006), Frampton's (2007), Schumacher's (2011) seminal studies. The research puts forth the advancements, potentials, and problems of the recent technological/industrial revolutions considering the relevant social and organizational dimensions[70] and the collective form of architectural action. It also brings the discussions of architecture, its autonomy, the role of imagination, and creativity thoroughly.

The aforementioned objectives of the chapter, then, question the knowledge bases of those complexities further. It becomes impossible to generate such a knowledge of subject-environment-technology togetherness without considering the complexities of the built environment as a culture, modernism, and its contradictions. On the other hand, the study's critical stance is motivated to catch the instrumental sovereignty of technology over nature's rules without creative combinations. Respectively, the study further claims to explore the new means of computation, modes of collective organizations, and spatiotemporal practices in a creative manner towards the third paradigmatic turn. The study, thus, starts with the search of the first turn as a result of the human-artificial interaction that generates the set of multiple reference systems in the built environment under the influence of industrial revolutions extending up to the creative tools of technology with the capability of self-reproducing information.

3.1. The First Paradigmatic Turn of Architecture's Creative Evolution

This chapter considers the multiplicity of the emergent literature references in

[70] Additionally, beyond those circumstances in the definition of the profession's labor force it is to develop an ideologically conscious manner for the mode of organization of a new professionalization in the existence of technological revolutions. Such research reminds us of what the potential collective endeavor of such a conscious organization should be aware of first; as the new technological developments may infer to the new fragmentations and specializations within the definitions of roles and tasks of what Florida clearly puts forth (Florida, 2002).

architecture like Le Corbusier's, Giedion's, Frampton's, Jencks's, Koolhaas's, Tschumi's, or Lynn's, Frazer's, and Carpo's seminal discussions[71]. The study regards the emergence of the revolutionary grounds of Industry from machine to automation and digital culture with the change in architecture. After the initial experimentations on the steam machine with the scientific discoveries from Newtonian physics, the progress, for instance, was celebrated with the First Machine Age, as revealing itself initially in aesthetics and formal appearances. This epoch is related to the avant-garde movements with their strong repercussions on architectural and engineering structures extending towards the twentieth century. Electricity's discovery and its usage in production, then, was followed by the rise of automation. The initial examples in cybernetics in the following years signified the Second Machine Age.

The ongoing spirit of the age is pioneered by Cedric Price and Archigram's designs and by Reyner Banham's theories to integrate the human experience and its comfort conditions with the thermodynamic and kinetic aspects of the environment. Respectively, the automata studies to be integrated with smart architectural environments in this period also initiated the futuristic endeavors as in the case of Fun Palace. Until the rise of networked information technologies, the imaginary endeavor of this approach, however, remains essentially the same. Even though the rise of information technologies has shown remarkable progress with cybernetics, computing, sensory technologies, and robotics, it could only be possible to grasp the real potentials of what Objectile could mean to the production of architectural objects/environments in Industry 4.0 in the late 1990s and the 2000s.

Until this period, it is possible to discuss many pieces of architectural literature describing an evolutionary trajectory of modernity. Frampton's seminal studies on the modern culture of architecture, for instance, initially grasp the conflict between rationalism and organicism, between the agrarian society of Gemeinschaft and the industrial civilization of Gesellschaft (Frampton, 1992; 1995; 2007). The effects of industrialization also increased urbanization, as reflected in this first societal distinction between Gesellschaft and Gemeinschaft, which also connotes the primary differentiations even within authentic cultures. After the early bifurcation between

[71] For different evolutionary mapping study of references/bases in architecture, see also (Yeneva, 2012).

Gesellschaft and Gemeinschaft, this thesis studies that certain references like Frampton's or Jencks's works indicate the complex non-linearities in evolutionary mainstreams and avant-garde movements. Thus, it is possible to locate avant-gardist movements in the modern evolution such as Italian Futurism, Russian Constructivism, Surrealism, Dutch Neo-plasticism, and especially De Stijl movement, as well as the foundation of Bauhaus, by departing from the initial contradictions of the modern culture. Bauhaus in particular extended its influence later in rationalism and in the International Movement from Germany to the whole of Europe towards the USA and other developing countries (Frampton, 1992; 2007). Le Corbusier, similarly, analyzes the relation of Industrial transformation in correspondence to design and architecture that is inspired by large-scale machines and factories and the geometry with a new morphological continuum of space in '*Toward an Architecture'* (Le Corbusier, 2006).

Besides his seminal book, *'Modern Architecture',* Frampton deliberately divides '*The Evolution of 20th Century Architecture'* into four main chapters; as he also admits the challenge to reduce certain aspects of each avant-garde and architectural movement to distinct categories (Frampton, 2007). Frampton recognizes avant-garde movements and their continuity between 1887-1986; the distinction between the organic and rational styles between 1910-1998; international approaches and national impacts between 1935-1998; and finally, variations through developing technology and the new architectural and architectonic production between 1927-1990 (Frampton, 2007). Frampton's rational approach can also be reinforced with one of the most influential figures, Sigfried Giedion, in his book *'Space, Time and Architecture'* (2008) as one of the genuine references of modern architecture, reporting CIAM gatherings.

Charles Jencks's seminal study, *Theory of Evolution* (Architectural Review, 2000; Jencks, 2000; 2006), also focuses on the evolutionary trajectories from the rational thought of Modernity. Jencks clusters different modern architectural approaches with reflections of subjectivity in design as "Logical, Idealist, Self-Conscious, Intuitive, Activist, Unself Conscious 80% of Environment" (Jencks, 2000; 2011). Thus, the emotion-intense identifications and environmental concerns with the echoes of subjectivity can be regarded together with the role of creativity in design, industry, and production relations in Jencks's work. The subsequent postmodernist period's analysis in re-evaluating the classical architecture is manifestoed by Venturi (1972; 1977) as the rival 'competing paradigm' in architecture. The critical responses are also echoed from Manfredo Tafuri (1976) after 1968 events within the industrial forces that influenced the society, culture, and the profession/discipline of architecture. Charles Jencks (2000; 2006) also draws a clear picture of the emergent 'fuzziness' of postmodernism that is bifurcated from a simpler understanding of modernist architecture in his *Theory of Evolution* (2000).

In the ongoing period, contemporary architecture and design have also shown different approaches ranging from high-tech and neo-modernist culture to deconstructivist and expressionist manners. However, there can also be found scarce examples in stable evolutionary trajectories. The tradition of the Dutch culture, for instance, focuses on the modernization of their dense built environments that has never been a part of significant world war or class struggle, as distinguished from those fuzzy relations.

Architecture's creative evolution also recalls the logical and emotional states in performative action of the subject with its sensorial and imaginary contrivances and their transference through action upon the objects of perception and thought. Besides discussing autonomy and the models of chaos and complexity, the inquiry progresses with the analyses of the subject's sensual experiences correlated with logical decision-making processes in design, generating the evolutionary knowledge bases of architecture about technology, industry, and production. Respectively, the relations between the first and second nature (Sargın, 2000a) would encounter the convolutional complexities between culture-nature dichotomies, and correspond to the complex insights about spatiotemporal actions of the subject that would be scrutinized in aesthetic experiences concerning art and architecture evolved in time. The study maintains the detailed discussion of the evolution from avant-gardes to mass culture with regard to the key theme of performativity, and the evolutionary mainstream of architectural movements changing the built environment. The discussion is followed with the role of the spatiotemporal practices of university campuses, as discussed in the studied references (Frampton, 1992), with the role of autonomy on the one hand, and the built environment evolving with the influence of technology, industrial revolutions, and economic dynamics on the other.

3.1.1. The Modern Transformation of the Industry, Art, Architecture, the Built Environment

The Evolution of Performativity from the Modern Avant-garde Movements to the Mass Culture: The impact of the modern avant-garde art movements is invaluable since the performative act, as a modern idiom, is the most compounded and intensified form of action for learning in spatiotemporal experiences with an emphasis on the relationship with the transforming relations through industrial revolutions and technology. Most avant-garde oeuvre betokens for a series of unique spatiotemporal experiences that becomes an inspiring impulse for succeeding socio-cultural and even political actions shaping the built environment. Thus, in modern meaning, avant-garde art and aesthetics correspond to an idiom for being the forerunner of creativity and changing perception by technology. It is significant to introduce the debut of the evolutionary trajectory of the modern avant-gardes to activate successive learning processes in spatiotemporal experience[72] with their persisting and varying trajectories.

The modern avant-gardes give traces of the evolution of the culture-nature dichotomy departing from the primitive depiction of nature[73]. For a complete meaning, it would be preferable to refer to modern aesthetics in the early modernity of the twentieth century (Adorno, 1997; 2001; Erjavec, 2015). Not to make any erroneous interpretation of aesthetics in order to fully understand the spatiotemporal experiences of subjectivity, the modern avant-garde art, and the idiom of performance in modern times (Spiteri, 2015a; 2015b; Miller, 2015) would be useful to initialize the new parameters of evolution in time series.

The shift of the living environments from feudality to industrialized, urbanized cities have signified the developed countries' rationalization in the 18th and 19th centuries. In the proceeding period, the rise of the modern age, parallel with the advance in technology, has created efficiency in the mode of production, and has brought new possibilities of experiencing the material world. Those novelties have changed the established norms and beliefs in aesthetics as well as the constructed knowledge

[72] -as the winner input-
[73] See also (Erişen, 2016a).

towards the evolutionary understanding of the avant-gardes. The distinction between the relations of productions in mass culture and the values that were attributed to them from ancient times can also be evaluated as shifted. The theories upon the ugliness of the speed and change within the early modern industrialization accelerated the Italian Futurism conceptualizing the practicality of modernity and the rationality upon nature (Bru, 2015; Erjavec, 2015). Dwelling on the rise of technology and industrial development, Russian Constructivism was similarly inspired by the principles of modernity in material-based spatial design, production, and technology (Bowlt, 2015). The influences of the Bauhaus movement have also shaped Constructivism that was developed around the shift in scientific approaches, technology, and production influencing daily life. The aesthetic shift of the revolution of Russian Constructivism from existing forms of art into the constructions and material changes also integrated the functional needs of the city with new technological means, including the usage of glass and steel in constructions. Additionally, new building typologies and infrastructures have emerged, such as trading halls, movie houses, electric-power stations, water towers, natural-gas tanks, railroad bridges, radio towers, worker clubs, and social housing blocks (Bowlt, 2015). Surrealism, on the other hand, questioned the rise of second nature by having based its discourse on the autonomous realm of art (Spiteri, 2015). The revolutionary change in the perception of artworks was against the established rules of culture and the traditional norms of aesthetics (Shanken, 2009; 2012; Spiteri, 2015). In the 1950s, there were also a few other creative artworks revealing the shifting recognition as in the oeuvre of Maurits Cornelis Escher[74].

The rise of the culture industry (Adorno, 2001) with new tendencies; and the rise of Pop Art, yet with the critiques of the Society of the Spectacle (Debord, 2006; Erjavec, 2015; Spiteri, 2015a; 2015b; Miller, 2015) in the following period, were followed by the rise of mass culture in Industry 2.0, with a tendency towards new media and multiplicities by technology in art defining performativity (Ascott, 2000; 2003; 2006; Shanken, 2009; 2012). After World War II, an irreversible change with a desire to

[74] "Eight Heads" (1922), "Sky and Water I & II" (1938), and the series of "Metamorphosis I, II & III" (1937-1968) and then, "Regular Division of the Plane I, II, III, IV & V" (1957) reveal almost the mathematical fractal studies on the canvas. By integrating the artistic subjectivity through the new interpretations of architectural elements in "House of Stairs" (1951), "Relativity" (1953), "Convex and Concave" (1955), "Ascending and Descending" (1960), Escher's works have signified the transitive evolution of cognition.

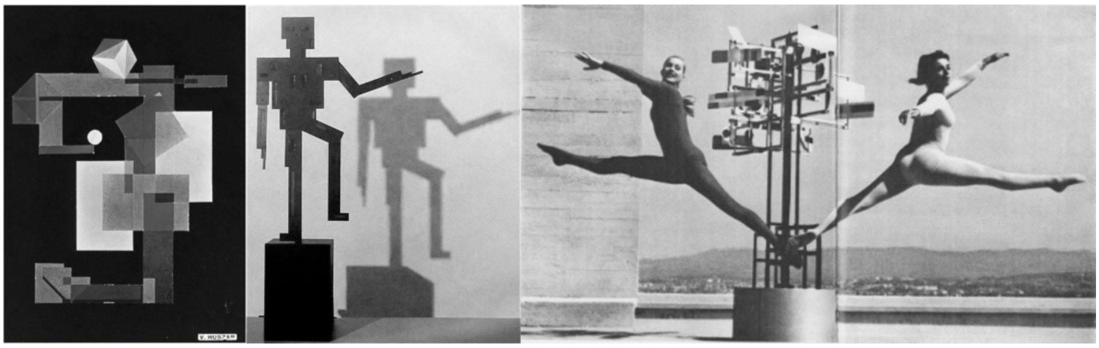
transform social and institutional formations was enacted in many geographies. The United States has pioneered the most ostentatious cultural change that we have encountered with the 1960's pop art that still exists in the form of mass culture (Miller, 2015). The power of new media has been touted to disseminate the effect of pop art worldwide rapidly with the slogan of individual choice for the consumer as the ultimate target of the consumer culture (Baudrillard, 1988; 1998). Pioneering the Situationist International movement, the French thinker Guy Debord, on the other hand, adumbrated the consumer culture in "*The Society of the Spectacle*" (1994, 2006). Instead, SI was focusing on the use of action, or the performative act, in the creation of 'integral art' through the non-hierarchical structures of 'construction of situations' with the idea of 'unitary urbanism' (Spiteri, 2015b).

Whereas Pop Art, focusing on the same theme of performance, showed some deviations from the critical works like the seminal work of Marcuse on the performance principle and its critical role in the changing societies of production and consumption (Marcuse, 1998). Thus, pop art's dialectical position has been ramified into different approaches. Herbert Marcuse's thoughts upon the liberation of labor against the turnover time has been exchanged with the desire of pop art on new bodily reactions of performativity touted in the culture industry (Horkheimer & Adorno, 1996; Marcuse, 1998; Adorno, 2001; Horkheimer, 2004).

The tendency towards new electronic media (Shanken, 2009; 2012) that is alien to the first and second nature, then, can be seen as the third nature of human creation, creating evolutionary parameters for Subjectile and performativity. The direct relation of mass culture with the globalizing media has started to exist as the most popular domain of artistic 'performativity', as the transformation of its art forms into multisensorial approaches. The digitalization of media becomes the novel domain of art that is eulogized with the thrilling supporters of technology as one of the candidates of the neo-avant-gardes in the information age regarding performative art objects.

Alternatively, the rise of science and information technologies also presents many opportunities, like the emergence of neuroaesthetics, that was seminally introduced by Semir Zeki (Zeki, 2009). As a fresh research domain, neuroaesthetics have the potential to extract novel synthetic concepts for performativity to be transformed from the ambitious and ambiguous state of the art into its possible formal relations when it becomes concurrent with new media and technologies like neuromorphic computers. The potentials in neuroaesthetics can also be fostered around the artistic performativity that corresponds to certain works in 'the science of consciousness' (Ascott, 2000; 2006).

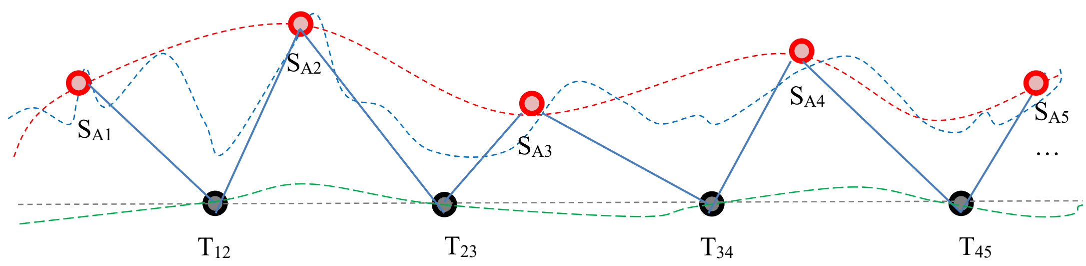
In that regard, modern art with a range of oeuvre can be regarded as the most substantial inputs for this new learning experience in neuroaesthetics and in the new forms of technology and performance in the information age. The significance of new media (Ascott, 2006; Shanken, 2009; 2012) to reconstruct performative experiences can be traced back, for instance, to the relation between the 'Mechanical dancing figure' of Huszar and the first cybernetic sculpture, CYSP I (Figure 3.1). CYSP I can be introduced as one genuine performative art object dancing autonomously, designed by the Philips company and Nicholas Schöffer (Figure 3.1). In the CYSP I project, as the first cybernetic sculpture, the inquiry is towards the perceptual and cognitive states of mind that are mimicked on the axis of happiness and other emotional states (Shanken, 2012). The modern abstraction of dancing figures in the development of artificial intelligence can also be regarded as one of the initial examples of developing performative human-artificial interaction by mimicking the emotional states of mind/body. The use of such interaction states, respectively, has potentials for novel abstract models in the research fields like neuroaesthetics (Table 3.1) (Appendix B).



(1) (2) (3)

Figure 3.1. (1) Vilmos Huszar, Mechano-Dancer, 1922, Private collection, New York; (2) Mechanical Dancing Figure, 1920; (3) Nicholas Schöffer & Philips Company, CYSP 1, 1956
Sources: (1) https://upload.wikimedia.org/wikipedia/en/d/d1/Huszar_mechano_dancer.jpg
(2) https://i.pinimg.com/originals/93/ed/c7/93edc700893a864c452f748e3a98e52b.jpg
(3) http://cyberneticzoo.com/wp-content/uploads/Schoffer-Cysp-_0039-x640.jpg

Table 3.1. Abstract modeling of different reference systems and evolutionary station points



Learning from the Architecture of Spatiotemporal Multiplicities:

> "Application of dynamic lines and moving shapes are being showed better in Mendelsohn's drawings as its correctness to show Einstein's relativity theory and thereby refute Newtonian concepts of space and time, which can be interpreted as a revolution in architecture parallel to revolution in physics. For example, the grids of reinforcement in concrete building form – exactly as the force lines of electromagnetic fields – fields of forces in the structure…" (Jormakka, 2002).

This short passage implies why the modernist rational thinking has been shaken by the relativity of particularities, which has become, in particular, the concern of the post-war period of everyday life in the developed countries. Even describing the amorphous attempt in Mendelsohn's interpretation of Einstein's relativity theory in his tower (1920-1924), it is meaningful to describe the unseen forces of interaction that are virtual to five senses and the traditional understanding of Subjectile. Yet, it can also be discovered in the digitalized media, as in the case of Kas Oosterhuis and Bouman's "Trans-port: Attractor Game for Reitdiep" project (Oosterhuis, 2003; 2008; 2014). This influential and evolutionary progress may somehow answer why architecture is a field of practice and research as highly influenced by the socio-economic movements that are concomitant with the changes even in scientific discoveries and associated with industrial and technological progress enjoining our everyday lives.

As we are living in the age of quantum gravity theories, the question is 'Are there any particular avant-garde or architecture movements that are extremely particular in a certain sense, though trying to synthesize Newtonian gravity with the motion of relativity in the modern age in a universal approach?'. Even though it lasted very short, De Stijl (1917-1931) satisfied this claim of being a modern avant-garde movement. It has a sharp manifesto for the changing world of individuality into modernity's universality, pointing out consistent progress. The correlation of art and architecture in De Stijl requires great attention for the further potential tracing prominent evidence for the togetherness of senses with practice as differing from other avant-gardes. The nationalist stream of De Stijl reveals itself as an international movement. This research is taken as a reference to evaluate the changing architectural and urban interventions with regard to its predecessors and successors of the Dutch culture as having a much more stable trajectory regarding comparison to other movements (Table 3.4).

Thus, De Stijl's experience rather corresponds to the existence of heterogeneous collectivity of art and architecture as a community of projects and enterprisers under an intellectual movement of the journal with the same name. The movement aimed to separate and combine the single elements into new and universal configurations to give an ideal model of a new world. Additionally, it can be claimed that none of the World Wars disturbed the singularity of Dutch culture as in De Stijl, even though they were detrimental to the CIAM movements of the modern architects in the further period searching for a similar correlation.

To better understand the consistency of the Dutch culture in the built environment, as one particular instance, it is necessary to grasp the successive inheritance of culture from Rembrandt to van Gogh that is evolved into Mondrian's studies with the changing perception in early modernity during the life of Berlage (Giedion, 2008; Blijstra, 1960). Berlage's close relation with Art Nouveau signified an ontological phenomenon of cultural endeavor with many artists and architects that belong to a very restricted territory. Many significant figures, Rietveld, Schroeder, von Doesburg, and van Eyck in the later period, represented a virtual revolution of architectural production besides Escher's influential creative artworks after the World War II period. The current period has been mastered by Rem Koolhaas, Winy Maas, Lars Spuybroek, Von Berkel and Bos, and many others in the information age. It interpolates a certain mutation of the cultural revolution in itself. Nevertheless, even this progress has already experienced a cultural and intellectual alteration in the influential period of Fred Koetter. This fact also shows the generation of the initial bifurcations and transferences in a higher discussion of the culture-nature dichotomy and the endeavor for their togetherness in the time series discussed.

The Rise of the Modernist Urbanism and City Developments in the Built Environment: To have a different view of creative evolution in architecture with regard to the evolution of the built environment by city planning and the urbanization practices, the reference point of the Dutch culture, in that regard, enables interesting inferences to be made. The evolution of the built environment with significant concepts and events can be checked/compared on the side of the particular trajectory of the Dutch culture that faintly reveals itself yet linearly (Table 3.4).

In the rise of the intense urbanization practices for planning the outline of New York City, for instance, 'The Grid' was diagrammatically rationalized and introduced into the planning of Manhattan Island as the new part of the discovered motherland of creative praxis of the Dutch colonies (Koolhaas, 1994a). The Grid, in the proceeding period, was observed in the creative destruction of Paris by Haussmann (Harvey, 1989). Le Corbusier also followed a critical approach after the spatiotemporal experience of New York City, with the integration of culture-nature togetherness compared to the schema of the Radiant City or the Plan Voisin (Koolhaas, 1994a). It is a solid alternative to the spectacular experience in New York City in Gotham's Towers (Koolhaas, 1994a), as just using high-rise buildings to offset from the limits of plots to get a more natural landscape and more fields to breathe and walk around. Le Corbusier's approach would also make the fundamentals of the planning functions in CIAM gatherings later. Most of the idealized cases of many European cities were analyzed and planned by the critical decision-making gatherings of the Athens Charter, focusing on this similar Grid schema. In that respect, it is crucial to digest the differences in learning mechanisms of territorial striations and smoothing of various geographical spatiotemporal experiences in the modernist city development principles in European modernity with the perpetual design and practice from the Dutch case.

The international European experience was maintained by Le Corbusier's Carpenter Center in Harvard University in addition to the experimental work of especially Gropius's Graduate Center. Similarly, Pan Am Building, the skyscraper of Gropius in New York City, as well as House in Wayland and Project for Back Bay Center in Boston, reveal the similar modernist experiences maintained in the geographies of the United States. It is possible to multiply the Le Corbusier's and Gropius's cases, Mies van der Rohe's Lake Shore Drive Apartments and the Federal Center building to reveal the international style of the European designers on the American soil.

It can be said that CIAM gatherings also enabled the precedent experiences of modernity at different geographies to be varied in the subsequent period. The fourth and most consequential CIAM gathering, the foundation of the "Athens Charter", traced out the urbanization of the Dutch culture back to Europe with a demarcation point after discussing the Manhattan experience. It was the first international meeting held in Athens; the discussion object was Amsterdam City itself with the decision processes of its urbanization further presented by van Eesteren, as the chief architect of the city from 1929 to 1960 (Giedion, 2008). What was spectacular about the autonomous modernity of city planning of Amsterdam, even before the CIAM's studies, was the initial social decision-making mechanisms applied by the inhabitants of each plot, as a tradition, making the city a paragon of urban design, besides Berlage's influential works (Giedion, 2008, pp. 793-813). This manner is unique in the freedom of the user deciding on the design, as in the case of the Free University of Berlin in the 1960s. Since most of the inhabited land was not sold but lent to the holders, the bureaucracy had created responsibility and a collective culture of making, which was somewhat altered from the colonial experience of the New Amsterdam in Manhattan Island. Accordingly, the ultimate modernization in the extension plan of the south part of the island was implemented with the joint scientific research by the Department of Public Works (Giedion, 2008) by van Eesteren's shared CIAM experiences.

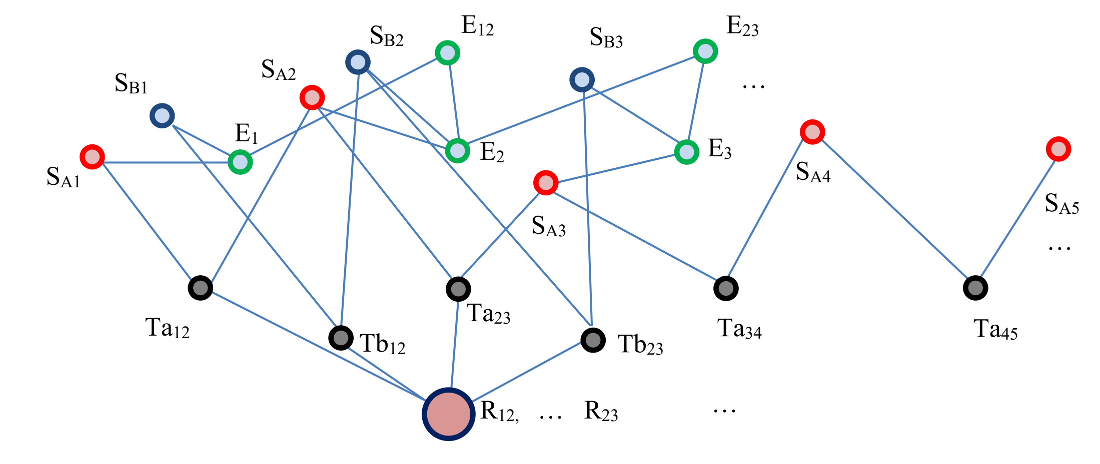
However, the overly rationalizing collective decision-making processes of CIAM can be criticized for traditionalizing the modernist approach since it is similarly reflected in almost all projects, even if just discussed in Amsterdam's particular case. The practical application of rational methods of the site planning distinguishing the functional utility of residential, industrial, recreational uses from the circulation as a modernist approach also restricted the further manipulation and renovation of city spaces and architecture. By surveying the industrial revolution and natural sciences, a specific search for a 'modernist morality' was also the concern of modernism, as Giedion claims (Giedion, 2008). However, this was again what prevented the modernist approach from being particularly successful, especially after World War II, due to its dependency on the rational mode of making influenced by the technologies of the industrial revolution. The early modernist experience led to that rationality, yet the architectural technology after the post-war period has revealed the increasing gap of the new scientific inquiry and new technology from the modernist experience. The disconnection of arts from architecture in most of the CIAM gatherings and especially in practice can also be ascribed to this era, describing the condition of architecture as being more steps back from the innovative development of art and the new media.

When considering all CIAM gatherings, it is also possible to trace some critical points besides the merits and ideological points drawn at the meetings. In the book *Space, Time and Architecture*, Giedion, as the last secretary of CIAM, outlines all gatherings. Accordingly, it is even possible to make a general critique of modernism as becoming almost a tradition of making and thinking, referring to a traditional contradiction of polarity between particularity and universality. The rising rationality focusing on the relentless scientific rules has concurred for uncompromising internationality. However, the paucity of the discussion on particularities in the meetings did prevent evaluating and interpreting contextual cases. These became ubiquitous but void-content imaginations about universalism, with some ideals upon *tabula rasa* without a territorial feedback mechanism. However, the meetings could be consequential to learn further from the rise of nationalism, particularity, the owner demands, and the dispersal of certain groups after World War II. Giedion makes a general critique touching upon the condition of emotions for these particularities:

> "Social, economic, and functional influences play a vital part in all human activities, from the sciences to the arts. But there are other factors which also have to be taken into account -our feelings and emotions…The feelings, which it is the special concern of the artist to express, are also at work within the engineer and the mathematician. This emotional background shared by such otherwise divergent pursuits is what we must try to discover." (Giedion, 2008, p. 430).

The modern experience of city planning with the lack of analysis of national/emotional states in the decision-making mechanisms of CIAM legitimizes an expectation of potentials of rising particularity. Accordingly, it is here to suggest that, since there are certain tendencies to gather artistic performativity of emotional states with architectural practicality, in the modernist experience, further collective experience could have contained particular insights upon emotional experience in spatiotemporalities. It is here to clarify then the collective experience, which requires the inclusion of decision-making processes correlated and concerned with the analysis of emotional states and their disturbances. This idea fundamentally explains the dynamic relations of ‘collective conscience’ in a systematic understanding of architecture’s creative evolution. Then, it facilitates an inference here: conscience, by definition, is used in this study to integrate the responsibility of conscious decision-making and judgment upon things by internalizing emotional states and their outcomes to understand the particular and volatile conditions. Grounding for an intelligent apparatus of action, in this sense, logical iterations should be revised with their associated emotional projections within and without. In that sense, an insight upon subjective performativity of action would be consummated through the variation of emotional disturbances, giving a justifying condition for further intelligent adaptability and creative responses. This can only be realized with the learning experiences concomitant with a collective conscience, provided not with a demanding and relentless decision-making policy but with a delineating analysis of emotions and subjectivity (Table 3.2)[75].

Table 3.2. Development of entangled connections for architectural references (model) via multiplicities of bases and references in creative evolution



[75] The emotional aspects are to be evaluated under the definition of ‘collective conscience’ or reference (R12) (Table 3.2) with the challenging change of fluctuations and the relative states of different reference systems of architectural and spatiotemporal experiences with regard to correlating artificial (or other topological agencies) and their evolution within. The further multiplication of agencies and references, and other references and parties as well (Sb, Sc, Sd, T2, T3, E1, E2, R12…) are denoted in the table respectively.

As described previously, the rise of particularity in the proceeding period after World War II and the rise of the post-war/postmodern period, however, did progress in subjectification of meanings and values as either textualized as critical narratives in literature, or otherwise found themselves in the flow of sign values. The profound meanings within this rise of the pleasure of sign on architectural objects become historically sublime once again with its transferences to the subject via the new age's objects. By this time, the rise of the culture industry had accordingly surrogated upon the spectacle's society, whereas even the integration of art correlated with architecture's practicality has turned into a culture-oriented extrapolation of the subject (outside itself) to an object of *jouissance* fostered by the ideology of popular culture. Converse to the manifesto of De Stijl, as well as to many other modernist approaches, it refers to a pre-modern period. The interest was towards eradicating modernity's subsequent rationality with a pompous and verbose subjectivity in every sign, as we have learned from the Las Vegas case. This critical efface of rationality has transmitted into the objects of pleasure and excess, evoking illusory signs of things.

Thus, it is possible to analyze the condition of postmodernity as an atavistic approach of collages in a piecemeal manner just to eradicate modernity. Even the work of 'The Collage City' by the Dutch thinker Fred Koetter and Colin Rowe (Rowe & Koetter, 1979) revealed an aversion from a mode of making, as this could only be substantialized in representations in between the real and imaginary by the popularization of the symbolic. So, the emotional particularities are somehow distorted in the postmodern, which can be criticized with its undiscovered potentials after the last world war by not efficiently utilizing even technology, but only trying to realize a virtual and symptomatic alienation of architecture from itself as a traditional contradiction. Instead of preferring to discuss architecture beyond representation and archetype, the environment becomes to be seen as coming from its reflected representational traces in the architecture of 'misrepresentation' (Venturi, 1972; Venturi & Brown & Izenour, 1977, p. 130). Consequently, the architecture of locality was misrepresented and converted into a sign with the illusory *jouissance* of the capital flow (Žižek, 1989). However, the critical text in "*The Long Island Duckling*" from *God's Own Junkyard* (Venturi, Brown & Izenour, 1977, p.17), concerning the message, has some merits to learn further from modernity.

Deconstructivism's influences on the built environment: One of the authentic examples in juxtaposing idiosyncrasies of individual emotional states, neither with a complete modernist nor with a postmodernist approach, can be observed in the design of Parc de la Villette. Tschumi's design is a unique example realized in the language of 'Deconstructivism'[76], with its intellectual background, to discover and superpose the previous functional usages[77]. The distortion of constructional planar surfaces in the dynamic equilibrium creates intensified experience points, *folies* ('madness', in English) at specific locations in the park ordered on a certain grid system, tracing out the previous savings of the modernist city planning. However, the project's theoretical background had been shaped for years, starting from the 1970s, through the 1980s until the 1990s, as Bernard Tschumi documented in his seminal essays upon space, "Essays on Space; Program; & Disjunction" (Tschumi, 1994a; 2009). His corresponding studies point out a relentless confluence of means and structures, with the flow of signs and representations substantialized and distorted with emotional projections. The formation of this progress has also been fruitful due to the laborious analysis upon *The Manhattan Transcripts*, with the insights upon distorted, superposed, and entangled geometries of points, lines, and surfaces, as satisfying the givens for the competition project of La Villette (Tschumi, 1994c). Outlining the primary frames of the further critical studies like *The Manhattan Transcripts*, such studies signified the changing urban scale parallel with the shifting perception. The related visual motion of the human eye combining the stroboscopic studies in time as in Giedion's *Photomontage* of Rockefeller Center, addressing the shifting perception in Edgerton's speed-photographing (Giedion, 2008, p. 851-856), has required that the related critical and theoretical works be grasped to understand the spatiotemporal action in terms of discrete as well as in sequential recognition (Figure 3.2)[78].

Similarly, Kevin Lynch's authentic findings with a group of researchers at the Massachusetts Institute of Technology to read the city space critically in the rise of signs and symbols since the 1950s, on landmarks, edges, districts were interpreted as

[76] See also (Tschumi, 1988; 1994c; Crysler, Cairns, Heynen, (Eds.). 2012)
[77] As being one of slaughterhouse opened in the late 19th century and demolished in 1974.
[78] See also (Deleuze 1997a; 1997b; Lefebvre, 2004; 2007).

points, lines, and surfaces, and have been applied in the interpretation of the competition's program. This fact was shared by the Dutch architect, Remment Koolhaas, as the other competitor, for whom Mitterrand's retinue's ideological suggestions were dominant (Koolhaas & Mau, 1995).

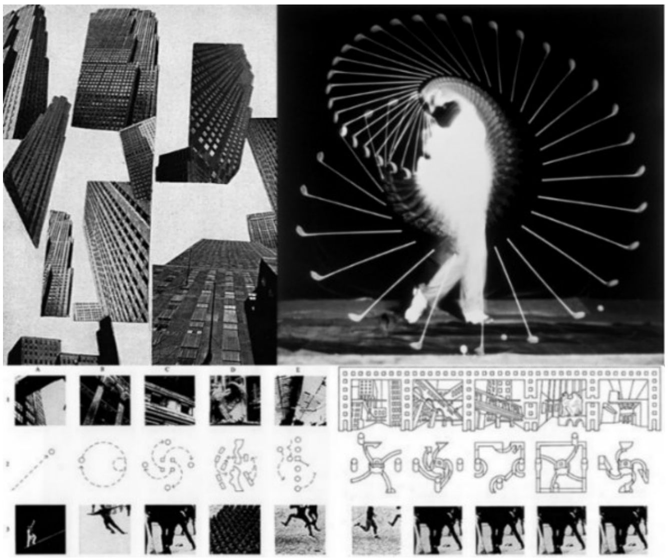


Figure 3.2. Giedion's photomontage (above left) (Giedion, 2008), Edgerton's speed photograph of golf stroke (above right), the Manhattan Transcripts of Bernard Tschumi (below)

Thus, Parc de La Villette was a new approach to designing the superposed schema by dissolving the totalitarian unity of elements into compounded points of subjective experiences. On the gridal planning surface, modernity's rational approach is discretely ordered with the intensification of subjectivity by constructed structures, *folies*. The approach can be seen as utterly creative as evaluating the site, as formerly allocated for slaughterhouses, that was turned into an experimentational park. La Villette project also evoked a neo-modern approach in planning. The site's historical content also required a strategical, creative, and critical positioning in either opposing or handling the supposed program with a literal understanding. The slaughterhouses' existence, dating back to the 1860s, was dealt with in a different manner in the design. In Tschumi's project, the intensified points of spatiotemporal experiences, *folies*, neither completely eradicate nor reminisce but compress the emotional projections as signifiers for the site of subjectivity (Hays, 2009). In this sense, the discontinuous order also shows an internalized architectural ideology, against such a place to break the symptomatic experience of *folies* that might make the project successful as fundamentally different from Koolhaas's continuous strips[79].

The Generic Architecture and the Built Environment in the Contemporary Age: Starting with the Manhattan experience, the voyage of modern planning has also been highly influenced by the Dutch cases by the ordered intensification strategies. Coming to the recent years of the information age, after the experiments in deconstructivism, planning the cities and built environment has still gained popularity, respectively, as a result of the desire for constructing big. Respectively, it enables us to talk about the emergence of many 'generic' Manhattans worldwide. This trend has emerged in particular regarding the rise of information and construction technology, with an immediate connection, decision-making processes, and their practice on the site in a short time by the digitalization of information for the perpetual substantialization progress in construction. Most of the generic cities have been clustered around the new capital hubs of the Middle East, in cities like Dubai, Abu Dhabi, Doha, and the cities of far Asia like Singapore, Kuala Lumpur, Shanghai, Beijing, Taipei. This growth pattern has also implied immense developments in Africa (Koolhaas, 1994b; 2004; Koolhaas & Mau, 1995; Koolhaas & Boeri & Kwinter & Tazi & Obrist, 2000).

Thus, it still becomes possible to pursue a metamorphosis of the Manhattan planning with the Dutch spirit since the first Athens Charter meeting. Amsterdam or other cities of the Netherlands have become the territories of the reformation in the city planning with the changing infrastructural projects associated with social and environmental facilities in the Millennium. The evolution of the city fabric with the inherited masterpieces of Berlage's attempts on the early modernization has been transformed into hyper-modern infrastructural developments. Regulating the circulation and greenery, but again with a heavy development of densification strategy, has been synthesized in a very amorphous language of the information age. In the Dutch case, the larger-scale city developments revealed the implementation of offsetting from the center of the country as a reservation for greenery[80].

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[79] In Koolhaas's schemata, it was to dissolve Downtown's Athletic Club plans to be scattered down to the earth; with an approach to design the landscape and yet with hostile approach to the historical urban fabric with a serenity (Koolhaas, 1994a). To allocate space for the program, Koolhaas spent more time on calculating "$\sqrt{((A-a)/x)}$" (Koolhaas, 1994a; Koolhaas & Mau, 1995).

[80] -interpreted from the lectures of Baykan Günay describing the Dutch decision-making on the urban planning.

On the other hand, many regularizations of waterfront projects with a series of social housing, cultural and recreational facilities in the Dutch case have been applied and reinterpreted in the information age after the CIAM experience. Among the most well-known ones, *The Whale* (2000), *Silodam* (2002), *Schots 1+2* (2002), and indeed many other waterfront projects, have made the Dutch architecture still local but with an international attitude towards making (French, 2008), showing a remarkable evolution from the 17th-century Dutch houses but still designed in a dense environment. As a reflection of worldwide known practicing architects in the last generation, Rem Koolhaas, Winy Maas, Lars Spuybroek, UN Studio, von Berkel & Bos, as well as some neo-avant-garde manners of Kas Oosterhuis, have exploited the potential of informational media. That occupies a consequential place for the Dutch art and architecture, which has not mitigated in years but exponentially ascending in effect, compared to the influential impact of the one-century-old De Stijl movement.

Relatively, the contemporary condition that has evolved from the impact of the Deconstructivist epoch can be described by the existence of many larger-scale design companies with different approaches. Norman Foster's studio of Foster + Partners maintains a relentless neo-modern approach of rational performativity, and innovative design procedures, whereas Gehry's focus is on sculptural form utilizing digital media. Koolhaas has versatile manners in the professional practice with OMA; and AMO. On the other hand, the evolutionary history of Victorianism of Chicago School also reveals the standing impact of SOM. Yet, it is still hard to tell whether Foster + Partners's approach always indicates practice in a high-tech manner; or whether Gehry and Koolhaas still maintain the 'tradition' of deconstructivism in the professionalization of architecture. What is significantly clear is that the most efficient approaches that are preferred by significant clients such as Apple or Google in the current condition imply the simple neo-modern productivity with the rules of design based on the efficient manipulation of form and function. Foster + Partners, or BIG Architects with a tracing line of the impact of MVRDV (MVRDV, 2005) or UNStudio, could be entitled to master this approach in the passing years.

3.1.2. University Campuses for the Autonomy of the Built Environment

With the aims of the thesis to evaluate the role of the built environment in collective organizations and knowledge generation in new subject-object-environment relations, the role of universities has a distinct place to be studied when even regarding the literature on the modern architecture and built environment (Frampton, 1992). The modern merits of University and its modern definition by Humboldt in relation to the state's role and power of the modern principles (Humboldt, 1969) correspond to a state of autonomy of knowledge production and its socio-cultural and spatiotemporal practices that we inhabit. Firstly, this aspect generates the dynamics behind the discourse of autonomy by the spatiotemporal practices of campuses *per se.* It is also significant to argue the role of the discourse of university in the evaluation of collective intelligence and its knowledge generation when regarding 'the real' in the production conditions of industrial transformations. 'The discourse of university' has a collective role in defining the battery of signifiers and symbolic meanings of cultural values and its knowledge generation (Lacan, 2006a; 2011a), which are accompanied by spatiotemporal practices. On the other hand, the rise of capital funding, besides the industrial revolutions and other significant externalities of the World's conjecture, also appear in the major transformation of education sites.

Educational campuses, respectively, can be appraised as the sites of production of knowledge and information or knowledge-intense performative acts of the creative subjects. Additionally, by the substantialization of scientific theories as associated with the emancipation of humanity practiced through its sites of spatial production, the claim of autonomy of idealized spatial practices of universities and colleges can also be alleged to act as an opposing force to the hegemony of economic decisions and power relations. Having a direct relationship with the externalities of industrial revolution and technology on the one side, and the sites of autonomous knowledge production with the scientific rules and principles on the other, universities stand for the generation of different approaches in the evolution of the built environment.

It is possible to have discrete and sophisticatedly correlated entanglements between the post-war post-industrial period of the 1960s and the emergence of the discourse of university in response to the change in socio-cultural and economic conditions that give a particular example in the practice of the Free University of Berlin. With a postmodern discourse to have a social and historical analysis in the generation of autonomous university space against the rigidities of modernism and urbanism of CIAM, the Free University is a significant megastructure as an architectural reference. The socio-cultural construction of the campus stands for the ideology of social function of space (Frampton, 1992), but also touts for the autonomy of their users in the spatiotemporal production (Candilis, Josic, Woods, & Schiedhelm, 1999). In the same manner against the rigidities of rational mass production, Alexander follows the critical regional style in his Eishin Campus in Japan in the same period. It represents the concern against the rise of Just-in-Time production that signifies the flexible mode of Japanese manufacturing. Respectively, the autonomy of university space again shows itself off in Eishin Campus, just as another example. The modernist Carpenter Center is located in a creatively tilted position in Harvard Campus in Boston against the existing neo-classical style of the industrial urban fabric.

Conversely, it is possible to follow the progress of industrial revolutions and other significant externalities of the global conjecture in the production of space with the scientific and technological endeavor that coexists with spatiotemporal progress as in the case of the MIT Campus. With many other singular examples that increase in number, especially in the 2000s with the rise of informational technologies in Industry 4.0, the progress towards the discourse on Objectile ought to be understood as an evolutionary transformation in the production of sites of academic knowledge.

The Free University of Berlin: The role of institutionalization has a consequential place in the embodiment of the architectural knowledge signifying the discourse of university and the autonomy on space. This distinct endeavor of the architectural praxis has been achieved by altering the scientific inquiry regarding user demand after the crisis of production. The rising socio-cultural and economic conjectures can thus be read with the rise of the social concern[81] in the design of campus by the members of TEAM X during the late 1960s (Architectural Association, 1999; Feld, 1999; Lefaivre, A., & Tzonis, L, 1999; Schiedhelm, M., 1999; Wagner, 1999) (Figure 3.3).

[81] -as in the case of the emergence of the discourse of university. See also (Sargın & Savaş, 2012; 2016).

Figure 3.3. Free University of Berlin, 1969-1970 (AA, 1999) (Left); The Free University of Berlin's additional library, by Foster + Partners, completed in 2005 (Right) Source: (Foster & Partners, 2017)

Regarding the role of 'the discourse of university' with respect to the coexisting rise of the events of 1968, it becomes much more meaningful, then, to understand the genuine approach of Woods, Candilis, and Schiedhelm in the Free University of Berlin. Due to the students' profound survey in the emergence of the exact spatial scheme of the site, the campus reveals an evolutionary experience departing from the earlier merits of CIAM gatherings (Erişen, 2018b; 2020b). The architectural experience in the Free University of Berlin integrates the rules of making with respect to the principles of nature, engaged with the desire for freedom and the demand for utility. This project correlates the cultural endeavor of freedom with the order of scientific rules of nature. The design creates a rehearsal from the culture-nature dichotomy into the togetherness of the first and second nature by integrating the user feedback, being superposed with the ideology of practical making of modernism as using the consistent schema of Römerberg (Frampton, 2007; Erişen, 2020b) (Figure 3.3).

Team X's members in the Free University of Berlin altered and revisited the principles of CIAM such that the reality of science of modernity in making has been engaged with the humanitarian approach in design decisions. Therefore, the designers make us once again concerned with the hybrid solution in this campus design. Furthermore, incremental contemporary intervention at the scale of architectural level by Foster (Figure 3.3) seems to have a language that reinterprets the needs of the user of the campus concerning the changing means of production and architectonic capacities again.

However, the post-war period's resultant factors still reveal the minor criticisms that can be attributed to the segregated urban formation of the Free University of Berlin. Evaluated in the conquer of technology and economic development, it is reasonable then to present the argument that "in-house universities are completely depended upon the external funding sources" as Castells studies, and it shows the importance of "synergy" (Castells & Hall 1994) and "intelligence" in the design of the built environments. Integration of the campus with the city as a critical discussion is germane to redescribe the contemporary condition of information flow and grasp the architect's role in the changing master-slave relationship in spatial production.

Accordingly, it can be criticized that the integration of the campus of the Free University into its immediate environment seems to have been limited. The low density and almost suburban environmental development of two- to three-story houses around the campus reinforce this argument. The existence of start-up companies or large-scale production manufacturing, technology, or service environment as an opportunity, just as in the case of Silicon Valley or even Boston Route 128, seems to have been missed out. Once defining the importance of integrating the university environments to high-technology sites, the urban fabric may generate certain grounds for further development; and nourish the spatial aspects of the built environment of university space both socially and economically.

It becomes significant, then, to consider the immediate environment of such institutional environments and their mutual relationships. Having an even more audacious approach with its contextual positioning with the same language of modernity, the Carpenter Center, in the same epoch of construction in the campus of Harvard University (Giedion, 2008), in that sense can be compared with its cultural and spatial discourse on the same basis of ideology and desire (Figure 3.4).

Carpenter Center (Harvard Fine Arts Center) & Post-war period Architecture: Thus, there can be found another way of interpreting the environment from the reverse side to represent the rise of the new and modern way of making and production, just as in the case of Le Corbusier's sole design in the USA, the Carpenter Center. Nevertheless, when considered in its period, it can be said that Le Corbusier designed his building as controversially creative to the existing city fabric, which best represents the traditional industrial environment of Boston. Carpenter Center for the Visual Arts, designed in 1960-61 on the Harvard University campus, thus shows off a converse approach as a manifesto of the modern way of making in the maximum freedom of the autonomy of architectural practice, giving shape to an educational environment. The rotated building mass contrasts with the neighboring plots of the Georgian style architectures as it divides the plot into two with its dynamic positioning and creates a new solid-void relationship. Distinct from the existing urban fabric, as an architectural embodiment of cultural endeavor of the autonomy of art, Le Corbusier's design was a challenge to the existing architectural conventions, technologically, tectonically, and spatially (Figure 3.4)[82].

Figure 3.4. Carpenter Center (Source: Carpenter Center, 2020)

It is the confluence of ideology and desire in variant degrees in the emergence of such projects as an action in time that makes the discussion grounded upon the relevant basis for the entirely different approaches, such as the Carpenter Center, the Free University of Berlin, or Alexander's educational Eishin campus as an experimental approach in Japan. Even though they seem incommensurable to each other in any other means, the singularities to be found in their evolutionary transformation with accompanying industrial revolutions and the socio-cultural concerns make them distinct for creative readings.

The Rise of the JIT (Just-in-Time) Mode of Production and Postmodernity: The extravagantly futuristic and stylistically contradictory construction of the Carpenter

[82] See also (Kural, 2015).

Center corresponds to what Alexander hypothesizes as the ideological inhibitions in the design approaches in system B (Alexander, Neis, & Alexander, 2012). According to him, these modernist rigidities were challenging in the decision-making mechanisms in the design of the Eishin campus.

The rise of the Just-in-Time mode of production in the late 1970s and 1980s can be attributed to the Japanese company Toyota as 'Toyotism' (Castells, 1996). The Post-Fordist industry period, so to speak, has also received some controversial responses in the built environment. Christopher Alexander's traditional design at Eishin Campus in Japan followed a humanitarian approach rather than the finished architectural edifices since the campus needed a design with the full hope and desire regarding its users' predilections as in the case of Free University. Stylistically, it refers to traditional Japanese architecture as a resistance against the corruption of societies under the influence of rush internationalism in the 1980s. Yet, this approach must not be regarded as a fall into the same stylistic error of post-modernism.

Thus, Eishin Campus has a user-friendly approach by integrating the beliefs of teachers and students about the brutal nature of the late 20th century (Alexander & Neis & Alexander, 2012), similar to the decision mechanism for the Free University with the rising concern of the negative externalities of industrialization. The Eishin Campus design represents the anxiety about society's corrupting values in its particular duration. The controversially creative approach of Alexander is somewhat similar to the campus design of Virginia University. The Eishin High School's design, for instance, was extended to a university campus organized with a series of colleges by organizing its college buildings around the green courtyard with an arcaded pattern of entrances (Figure 3.5). So, Eishin Campus can be given as a discursive practice that comes along the way of the reappraisal of traditional values against popular culture.

The project's adaptation to its environment was biophysically evolutionary. The motion of life-changing patterns around the built structure has also affected the adaptation of buildings in a reciprocal relationship. Then, the question may be upon how the flow or motion of that changing life-rhythm pattern can also be implied in a certain way, or how a different socio-cultural, economic, and demographic environment can be imagined so that the evolution of building masses' adaptation can also be acclaimed as revolutionary. Just to displace the linear contradiction between the inner sense of ourselves and the mechanical demands of production, Alexander distinguishes them as separate in "System A" and "System B" with their discrete and dynamic projections (Alexander, Neis, & Alexander, 2012). As similar to the paradox of Alexander's title 'the Battle for Life', the third chapter thus attempts to find the ascribed compounds in the existence of the rational death and the desired live instincts, in confluences such as culture-nature togetherness. This dichotomy also corresponds to a unique pattern language to be extracted out as a learning experience that should be reinforced with remembrance associated with emotional states. This learning experience emerges within and without the individual. It emerges within the subject in the internal conflicts of discrimination and the bias, in learning and understanding, in judgments and decision making influenced by the immediacy and retrieval of action through emotional states and earlier experiences. It emerges outside of the subject under the forces of natural, biological externalities that should be understood with the conditioned stability as well as alteration and change.

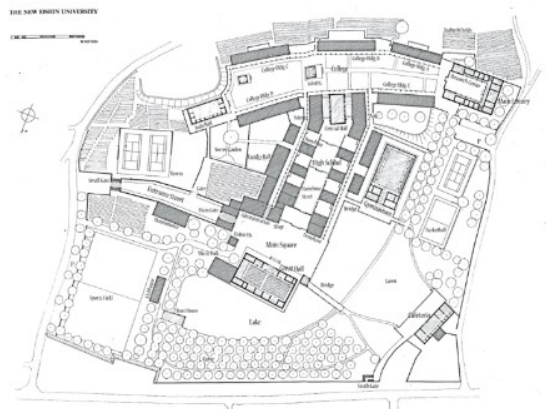


Figure 3.5. The New Eishin University, (Alexander et al., 2012)

3.1.3. The Parallel Evolution of Industrialization and University Campuses: The Case of the MIT Campus

William Mitchell tells one of the most peculiar stories, the MIT's campus design with its classical/Victorian as well as modern references as well as the newly designed buildings in the 1990s and 2000s (Jarzombek, 2004; Mitchell, 2007), which suitably represent the places that we live in with historical roots and evolutionary transitions by industrial/technological impacts. The campus reveals the demand in the high-tech funding economy in the spatial development as a research university besides the multiplicity of many architectural references in the recent decades.

The MIT campus's evolutionary transformation starts with a change in the classical roots under the influence of Victorianism and Classicism. Thomas Jefferson's initial idea for the first campus was to have the togetherness of the classical style[83] with a bucolic green environment, similar to the campus design of Virginia University, designed by Jefferson in 1820. The style of the campuses with their central squares having natural landscape/waterscape elements and inspirations from the classical as well as Renaissance forms can be attributed to Jefferson's style. Integrating classicism with American Victorianism in the innovative and pragmatic approach of erecting structures has also influenced the Chicago School. Based on Taylor's management principles, the main complex's construction process, including Killian Court with the Palladian/Jeffersonian dome designed by Bosworth, has been a symbol of campuses in the USA under the impact of the industrial revolution (Mitchell, 2007).

During World War II, MIT was one of the major innovation and technology centers due to the impact of Boston's Route 128, the Technology Valley of the war economy (Castells & Hall, 1994; Mitchell, 2007). The campus, then, transfigured its appearance into a pragmatic and tautologically iconic modern style. Mitchell reports that 'Building 20' was turned into the function of a Radiation Laboratory, and the Bush Building designed by SOM was the ultimate successors of the Chicago School, as the investments of that war economy (Mitchell, 2007). Eero Saarinen, a well-known architect through many monumental and spectacular projects besides simpler/pragmatic housing typologies in the USA[84], was later recruited to design the two iconic buildings on the campus, Kresge Auditorium and MIT Chapel. The proposals of Student Union and Graduate Center buildings were common in the same proposed site plan (Mitchell, 2007), and indeed this has revealed the persistent icon of the innovation with exclusive modernity of Saarinen in the USA. Parallel to the move

[83] See also (Jarzombek, 2004).
[84] Such as Demountable Space, see also (Shanken, A.M. 2009).

of Mies van der Rohe to Illinois Institute of Technology, and Walter Gropius to Harvard, the recruitment of Saarinen for the design of the campus and many buildings starting in the 1950s, besides another Finnish architect, Aalto's Baker House project, do not seem even accidental regarding him as the star architect of 1950s (Mitchell, 2007). The decision signified the success of Saarinen's pragmatic and even iconic designs in the rise of new consumerism and popular culture even during the 1940s (Shanken, A.M., 2009).

The emergences of other peculiar and iconic designs in the campus, as in the ones of Frank Gehry, Steven Holl, Kevin Roche, Charles Correa, and Fumihiko Maki, are part of evolution for an exclusively innovative approach for the development of the campus (Mitchell, 2007). Mitchell discusses the five major works as Zesiger Sports and Fitness Center with reference to the design of Saarinen's Kresge Auditorium and the Chapel, as well as one of the largest dormitory structures: Holl's Simmons Hall. Gehry's Stata Center, Correa's design for Brain and Cognitive Sciences Complex, and Maki's Media Laboratory are other three projects (Mitchell, 2007). The budget share for the projects was also spectacular, yet it was not enough to rule out the funding shortage in the end because designing for the 21st century campus has internalized the dynamics of information technologies. The three projects, Simmons Hall, Stata Center, and Brain and Cognitive Sciences Complex, show off the integration of the extravaganza of the freestyle of designing and making with advanced technology and the loaded programmatic and functional necessities with greater expenditures (Mitchell, 2007). On the other hand, the changing educational programs and necessities of those universities revealed the accompanying process of design that is transformed with informational technologies, as in the cases of Stata Center, Brain and Cognitive Sciences Complex, and the Media Laboratory. The design of Stata Center (2000-2004) also revealed the revolution of digital design with the help of the physical and 3D models and the exploitation of accompanying CAD/CAM technology of CATIA.

Taking the place of Building 20, Stata Center's structural challenges and the expressive form was hence again managed by the rise of informational technologies revealing the emergence of non-standard edifices in Industry 4.0. With many inner-space qualities that are designed according to the domain of research and surprising infrastructural integration of the tramway line passing through the building at the ground level, Correa's design has housed the most innovative and interdisciplinary research on the campus with its program having stunning research donations around $400 million (Mitchell, 2007). It shows the rising quality of the spatial environment that would be in harmony with the demand for the development of those research universities, revealing the necessity of the special design of the built environment.

The possible itinerary between the universities and the startup high-technology companies, back and forth, in the shift of the technology transfer is also explained by Mitchell when discussing the design of the Center by Correa as a strategy to get back the forces of high technology. He also marks the necessary development of technology and innovation-related centers in the research universities nearby:

> "This also represents, in vivid architectural terms, a crucial shift in the economic role of research universities. In recent decades, they have increasingly served as core components of national innovation systems, centers of high-technology industry clusters, and producers of economic growth and nearby jobs- as in the Silicon Valley area surrounding Stanford, the Route 128 area on the outskirts of Boston, and the biotechnology cluster that has more recently developed in MIT's immediate Cambridge neighborhood. The key mechanism in this is the transfer of technology from on-campus laboratories to nearby off-campus startup companies that are largely run by entrepreneurial faculty members, part-time student employees, and recent graduates. Urbanistically, the complex of new MIT laboratories defines the center of a growing high-technology neighborhood and reorients the campus to it." (Mitchell, 2007)

"The global multiversity" (Collini, 2012): With the learned feedback from the spatial production of the recent university experiences, architecture's role has been redefined. What is significant to learn in campus projects is the interconnectedness of the spatial continuity between the common university areas, different faculties, and the urban fabric, and its integration to economic dynamics. Multidisciplinary and interdisciplinary educational approaches, even by MOOC, have revealed the blurring boundaries at the international scale between the countries and the rigidities, with ever-expanding technology research even without spatial needs. Thus, online learning has urged new expectations on the spatiotemporalities of anew culture-nature togetherness, even exploiting technological means and potentials. The integration of the cultural richness of emotional variations of subjectivity seems like a further challenging task in front of humanity to be integrated with a new scientific inquiry. The spatiotemporalities in such novelties are expected to bind the higher sense of imagination and creativity correlated with sensorial activity adapted to the ever-changing conditions further by peculiar lab or intelligent environment experiences for the university environments and research centers.

The consequential changes in the modern times of the collective groups of people, focusing on rationalized and mass-produced standardized cultural and productive activity of the mainstream, have all been replaced with the networked oligarchic corporations and intra-national flow of information-sharing mechanisms. Regarding university as a space of production of knowledge and information in that sense, it is intertwined with the question of humanized technology in the practices and the knowledge generation in space and science. The speculative thing behind the processed information cannot directly infer or iterate certain conceptual forms of thought or substantialized formation of action. Instead, it returns elements of thought into the empty set of recursive relations. These ephemeral formations of the networked intelligence, in other words, the corporate and networked organizations, are nothing other than neo-capitalism's virtual connections besides the abstract form of the flow of values and things. The only thing that they attach to the real world is substantialized in spatiotemporal practices and property relations. The discussed procession of information manipulates the said disposition between the mental states and the environment. Thus, this process requires certain conscience for intelligent and adaptive spaces in evaluating performative action, perceptron, and mutation of evident information between the agent and the environment (Maoz & Yaffe, 2014).

Thus, the reflection of information to the practice of built environments of the universities has a significant place. Universities with futuristic projections regarding this informational transformation of spatiotemporal practice engage unified collectivities and consciousness. The propaganda of the style of the building, on the other hand, still represents itself in the cases of the singular objects of architecture as a demand of educational facilitation funded by notable corporations or sponsored by particular institutions. Gehry's design for Massachusetts Institute of Technology's Ray and Maria Stata Center; or Center for Computer, Information, and Intelligence Sciences; as well as Case Western Reserve University's Peter Lewis Building defer not only to the spectacular tectonic form, made of titanium and brick and revealing the continuity and discrete elements together, but also the functional need, especially on the technology-related research departments. Libeskind's School of Creative Media of the City University of Hong Kong; or the Graduate Center at London Metropolitan University are all striking examples of the subjective expression of form integrated with an arrested geometry.

Back to the campus design scale with a culture-nature dichotomy, Bernard Tschumi's proposal at Nice, Sophia-Antipolis Campus (Tschumi, 2004, pp.480-497) is a unique instance to talk about the agent's practice with context-concept dichotomy, advocating the interchangeability of the concept-context-and-content theoretically (Tschumi, 2004). Thus, many inspirational concepts are blended into the natural woods. The ideas for the language of the buildings range from Cezanne's unfinished paintings to the First World War's Military camouflage strategy that is condensed on a specific language. However, what is rather significant to follow in Tschumi's project is being a part of the older campus with a precedent aim for becoming 'the Silicon Valley of France'. Thus, the campus proposal has emerged with an idea of communication in the cross-fertilization of the research center, offices, laboratories, computer science center, sports center, and library. The idea of 'camouflage' as a confluence of ambiguous as well as ambitious states and creative inspirations simulate the flow of perceptional and emotional flows and energies on the two-dimensional plane since it "combines extreme similarity with extreme difference" (Zeki, 2009) by the help of digital technology of pattern recognition and generation. Nevertheless, it can be said that the plan typology of the educational buildings only resembles the mutant matrix organization of the Free University of Berlin with an "H-planned" schema organized around a central pivot of research center; that is in the manner of neo-modernist planning.

The OMA projects engaged with the planning office of AMO, on the other hand, ponder over the site with densification strategies as in the vertical campus, *Idea Vertical Campus* in Tokyo for MODE Gakuen in 2004. Like the Downtown Athletic Club experience, 67.000 m^2 would be configured on a regular urban plot, just like self-standing office buildings. Respectively, it is against the additional construction to the ground as a challenge for the tower building to create an inside-outside relation *per se*. Chu Hai College in Honk Kong with a 30.000 m^2 mixed-use program again signifies an overly densified approach. Compressed in a smaller zone of urban land, the reality of the age pushes the project just to construct levels over each other yet neighboring with a visual connection to the adjacent social masses of the design. The higher building mass with the shorter and larger social area, designed in 2010, can be regarded as one of the consistent design schemas in the contemporary age designed in dense urban areas. Similar approaches can all be represented as a withdrawal from the precedent American high-rise structuring that contradicts the interpolated subjectivity in Seattle Central Library (Koolhaas, 2004). The project is a stereotype promoting the digitalized immediacy of learning with the free space of event and experience spaces, freed from the structure, and expressed in the freedom of large voids. Even though it also betokens for the evolution of the institutional investments into the spatial reflections of the networked relations of economy, the informational age's reality still promotes touting via the edifices, as an opportunity for architecture, as they depend on the capital investment.

It cannot be seen as accidental, however, that the Dutch's densification strategies; or Far East cultures have a conscience about nature and its exploitation by the edifices. The Dutch culture still has highly dense population proposals and gives well-known examples of the culture-nature togetherness in education sites. *Mecanoo*'s TU Delft Library building integrated with the landscape, for instance, is one of the particular examples of a formal approach; and can be evaluated in principles of culture-nature togetherness (Figure 3.6).

Figure 3.6. TU Delft's Library, designed by Mecanoo (Mecanoo, 2021)

Mecanoo's designing principles, respectively, are in confluence with 'the Dutch style's initial suggestions' together with a 'pattern exploration' in the nature of things. The integration of the internationalist manifesto of De Stijl movement with the particularities, then, constitutes a concern of *Mecanoo* on the substantialization of a desired intelligence of architecture:

> "Architecture must appeal to all the senses and is never a purely intellectual, conceptual or visual game alone. Architecture is about combining all of the individual elements in a single concept. What counts in the last resort is the arrangement of form and emotion." (Mecanoo, 2017a)

Revisiting De Stijl's manifesto further, *Mecanoo* has the ten statements, which are the promising theoretical forces behind the motivation and synergy that still depend on the densification strategy yet with novel statements upon nature and sustainability (Mecanoo, 2017b). It becomes a global approach that can even be encountered formally due to the networked design and building processes. It is possible to resemble the National Kaohsiung Center for the Arts in China of *Mecanoo* in certain formal and conceptual respects with the similar dynamics of Rolex Learning Center in Switzerland. Similar to Sanaa's Rolex Learning Center, which represents the larger-scale complex building structure, the novel interpretations of voids, penetrability, access, and experience within the space are instances of contemporary architecture in contradistinction with the precedent examples.

Thus, the contemporary technique has enabled the confluential togetherness between the argument of technology and the ideals of designing. Yet, the information age is still disputable due to the virtual capacities of reducing the imagination and the knowledge into the modules of data and operations. It is still argued due to the conversion of the interpolated knowledge into the binaries of information thanks to the mechanized logic of technology. Since the transference of learning from nature, the first and second nature, would still maintain the major potentials for logic and imagination, the reality of the information age can be seen as illusory and ephemeral. As a concern of the collective conscience, in that respect, it should not be permitted that the sustainability and culture-nature togetherness would be a part of the advertisement strategies of the capital production while exploiting the networked information techniques and technologies.

3.1.4. Towards the Second Turn of Paradigms in Architecture's Creative Evolution

Industrial revolutions have influenced spatiotemporalities and architectural spaces as they exist in the classical reading of architecture regarding monotonous evolution. Respectively, it is possible to advocate the emergence of Deconstructivism again in response to constructivism's precedent effect when they are compared to the inquiry of space-time experiences. The revolutionary movement of deconstructivism ranges from Tschumi's photomontage to Gehry's surreal tendencies, Koolhaas's collage-like constructions, and Hadid's expressionist lines of motion, which inherit the modern avant-garde movements such as Constructivism. The movement has developed a critical approach against the restrained vision of the modern as well as the postmodern sign by further volatilizing the multiplicities.

Nevertheless, Deconstructivism cannot explain the current dynamics and confluential multiplicities by itself when regarding the recent impact of technology accompanying the changing paradigm of research of morphogenesis and action in architecture. The challenging question is 'How can those multiplicities be environmentally analyzed'; and the question necessitates modeling them for collective understandings. The possible relations for answering this question correspond to a completely different research agenda of science and technology that cannot be commensurable with the existing and almost classical domain of arguments on modernity versus post-modernity; or constructivism and deconstructivism.

Transformation by deconstructivism confers to transitive signs of progress, even starting with the agenda of the futurists, on the one hand, like Archigram, Superstudio, Cedric Price, Nicholas Negroponte, and, lately, William Mitchell, picturing the reasonable possibilities of architectural environments that are correlated with high technology. Further inquiry on non-linear complexities in space-time, regarding catastrophe theory, has profoundly influenced most designer-researchers, like Greg Lynn or Bernard Cache, revealing the fledgling grounds of the changing paradigm on the other side. The shift shows itself off in a complete change and different manner, especially integrating the digital media outside the culture of architecture.

Regarding Industry 4.0, the term Objectile by Cache is also closely related to this paradigm shift referring to the rise of new understanding that should be evaluated with a completely different agenda compared to the precedent epochs. The next section discusses the distinct and seminal approaches of Lynn and Frazer on evolution together with form, practice, and the relation of architecture with technology, natural sciences, and Life. It can be ensured that other than Jencks's and Frampton's seminal studies on the evolutionary change of architecture in the built environment, the rise of the new paradigm in coexistence with the evolutionary roots of non-standard production is actually missed (out) by those modern or post-modern readings. Since the digital paradigm is entangled with an entirely different agenda of scientific research on non-linearity and complexities, they are also not fully commensurable with the traditional arguments of organicism.

In that regard, the informational revolution and production ought to be evaluated under the key concept, Objectile. This concern can hence be seen as the actual shift from modern/postmodern dichotomy to the digital culture, and necessitates the recognition of an entirely new agenda of research of non-linearities so that it enables the entanglement of art, science, technology, design, and architecture to be read (Oxman, 2016). It can be said that Jencks's inquiry of the postmodernist search is utterly coherent in itself, even with the exception of his paper on *'Nonlinear Architecture'* (Jencks, 1997a; 1997b); indeed, there are many fledgling indications from Buckminister Fuller's innovative endeavor to Escher's morphogenetic and evolutionary transitions almost having non-linear dynamics in mathematical order. Accordingly, the inclusion of critical figures, such as Greg Lynn, Bernard Cache, and John Frazer, and what Jencks has already achieved in his evolutionary tree of 20th century architecture, increases the complexities in architecture to a new level. The exactness of digital technology by industrial influences, indeed, has turned the focus towards a new paradigm that gives directionality to information in processing architectural design and production. Accordingly, it is significant to introduce Objectile to correlate spatiotemporal experience concerning industrial production with the rise of the technological advancements of design and manufacturing and the new digital paradigm.

3.2. The Second Paradigmatic Turn in Architecture's Creative Evolution with the Genealogy of Theories of Non-linearity, Chaos, and Complexity

The second turn in architecture's creative evolution can be seen as the real paradigm shift by having a discursive reading on the corresponding research agenda on complexity in science and technology, reflected as the evolutionary trajectory of architecture since the 1990s. The research agenda is founded on the current digital paradigm searching for curvilinearity of forms other than the classical paradigm of modernity and its antidote, postmodernity. Accordingly, the theories of complexity have challenged the decision-making regarding the fuzzy relations between the cause and effect in actions that may enable to enumerate creativity models and discussions.

Henri Poincaré and his problematization of the three-body problem has acceded the theories of non-linear dynamics and discussion on topology dealing with the orbital motion of three celestial bodies, the Sun, the Earth, and the Moon in physics (V. Ivancevic & T. Ivancevic, 2012)[85]. With Poincaré's conjecture on the inquiry of the three-body problem after the rise of relativity and quantum mechanics (V. Ivancevic & T. Ivancevic, 2012), this shift has described the rise of the multiplicity of many scientific theorems and paradigms in science. This shift has also been apparent even in psychology and in neuroscientific research (Guastello, Koopmans & Pincus, 2009). According to Ivancevic & Ivancevic (2012), there have already been questions on unpredictable non-linear dynamics at the end of the 1800s that were later interrogated by Poincare's conjecture on 'the three-body problem' that could not have been solved by naïve classical mechanics' approaches. 'Ergodic hypothesis' simply re-questioned mechanics by the thermodynamics initially focusing on the motion of tiny particles. These investigations have given solid grounds for the studies on entropy, information theory, and the common grounds between physical and biological creatures. This progress was pioneered by Claude Shannon in his information theory, as well as by

[85] Poincaré conjecture has invoked the geometrical questions on the dimensionality of non-linear physics. Challenging the fully determined idea of stability and causality of everything in nature that is based on a stochastic linearity proposed by the first and the third principles of the Newtonian mechanics, further progress of linear mechanics with significant figures of Euler, Lagrange, and Hamilton, hence, has been alternated and fluctuated by the emergence of science of non-linear dynamics.

John von Neumann, George Birkhoff, and Norbert Wiener, that would lead to the novel approaches in computational neuroscience and human-computer interactions further.

Science and geometry-related research have also had greater impacts on evaluating innovative architectural endeavors and technological developments. The solidity of things as measurable with their crystalline structures, as Buckminster Fuller exploited in his geodesic domes, can be regarded even as computable, which extended until today in search of lattice structures at the quantum scale of things[86]. Such studies reveal the divisible matter in space-time, which gains robust rationality by the segmentations, parts of the whole structures that stand to be understood better by the computational logic and its newly developed vision. By analyzing the rationally divisible energy and entropy, such structures can be translated into mathematical computational states of things (Shannon, 1956) besides the *Mathematical Principles of Communication* of Shannon (Shannon, 1949). On the other hand, the morphology of organic forms also needs to inquire about the freely standing cellular voids and other hollow structures.

The emergence of things and their reproduction and growth through division can give way to the logic of self-replicating structures and systems that can even be observed in von Neumann's Automata studies (von Neumann, 1956). At this point, it is crucial to discuss the emergence of von Neumann's self-reproducing automata to describe the confluent states in computational means. Von Neumann, in his *The Theory of Self-Reproducing Automata* (von Neumann, 1956), was inspired by the common solution between the energy of biological neural mechanisms and corresponding logical and mathematical representations of computation as the multiplicity of different source states and their processes in his studies on 'Confluent States' (von Neumann, 1956, p.136; Beuchat & Haenni, 2000). Concerning the information theory that is all based on their entropy-related states and equations, his research has also inspired cybernetics and the literature affecting the digital paradigm in architecture.

Other significant figures such as Gödel, claiming against Russell's and partially

[86] See also a morphological inquiry of things with their subatomic Dynamics of lattice structures influencing their evolutionary form generation in (Kruşa Yemişçioğlu, Sorguç, & Özgenel, 2018).

Whitehead's rational approaches, should be discussed with his studies in the rise of non-linear vectorial dynamics. Accordingly, he was investigating the curvature geometries by his Incompleteness Theorem in response to the *Principia Mathematica* of Whitehead and Russell, further claiming that there cannot be a fully determined axiomatic system of science due to the uncertainty of those involved and chaotic dynamics. Poincaré did also raise a similar objection. In addition to these references, Ed Lorentz discovered one of the most well-known non-linear chaotic systems, as Lorentz attractors, by investigating the long-term meteorological forecasting that is theoretically explained by the togetherness of relativity and quantum fields as in the case of chaotic twin particles (Ivancevic & Ivancevic, 2012).

Concerning these discussions, Picon reminds **the challenges of decision-making** in architecture accordingly (Picon, 2010). The rise of non-linear dynamics has made one hundred percent decision-making impossible or at least possibly few if, and only if, there can be found ordinary or special attractors (Ivancevic & Ivancevic, 2012). The influence of the science of non-linear dynamics on the real conditions of life is also relevant today. Questioning the real life through turbulence systems, fluctuation in wildlife populations, the uncertainty of long-term forecasting, or non-linear dynamics uncover the years-old naïve approaches of classical science's professionalization (Kuhn, 1962, 1970). Ranging from geometry and novel algorithms of mathematics, physics, chemistry, fluid dynamics to biology, psychology, and unique engineering applications, the influence of non-linear dynamics corresponds to the dynamic mode of evolution that should not be pursued on a single line of developmental trajectory. Accordingly, Charles Darwin's developmental evolution of species and D'Arcy Thompson's search on the morphology and the variances on the emergence of things with their substantial forms are also the issues that ought to be considered by the delineate analysis of non-linear dynamics.

With the emergence of non-linear geometries and differential calculus from Riemann curvature and the non-Euclidean Geometry as well as Gödel's theorems on Incompleteness, the inquiry of D'Arcy Thompson in *On Form and Growth* studies the natural growth patterns of Life. With the rise of the information age (Castells, 1989; 1996; Sassen, 2001; 2002; Laguerre, 2005), these studies have become highly influential to be arrested by computational means as fractals, and to reshuffle the relationships between architecture and science. The sciences of biology and mathematics help to explore the strong elements of order, proportion, and their harmony in architecture and geometry. Respectively, D'Arcy Thompson investigates the growth pattern of cellular organizations and the transformation of the form of the body (of fishes, for example) (Figure 3.7) by the logic of topological geometries in the attempt to understand morphology with its form and energy (Thompson, 1917 (1961), p. 19)[87].

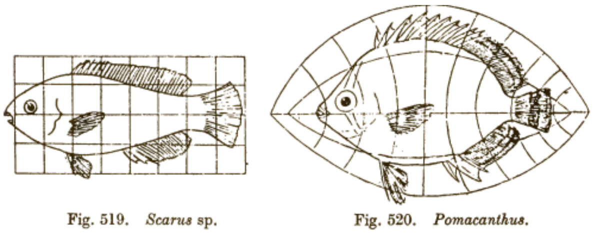


Figure 3.7. Topological correspondences by D'Arcy Thompson (1961, p. 1062)

Accordingly, Greg Lynn has retheorized the emerging digital paradigm with reference to topological geometries in architecture, deferring to D'Arcy Thompson's endeavor, as well as Cache's ideas on the technological object and space-time, which is highly inspiring for architects and theorists focusing on the natural form[88]. Like the concept of Bernard Cache's Objectile, Greg Lynn developed the idea of Animate Form (Figure 3.8) from his studies of moving objects by critically defining attractors through influencing physical forces.

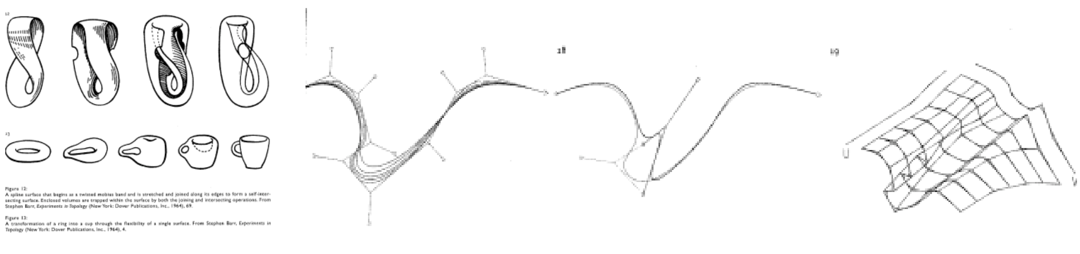


Figure 3.8. Animate Form (Lynn, 1999) with inspirations from the Klein bottle and curvilinear forms

[87] The rising impact of the freely growing pattern of organic forms such as the inspirational spiral arc and gnomon (Gazalé, 1999) to construct biological forms of seashells or other living bodies have been analyzed by the natural sciences of especially biology and mathematics.
[88] Even though there were many strives that Beesley and Bonnemaison indicate with some contingent reference to Frank Lloyd Wright in the early modernity (Beesley & Bonnemaison, 2008), Cache's attempt is unique.

With the help of the rise of the 'virtual reality' of the digital media, it becomes possible to analyze the objects, systems, and components in motion and their corresponding geometries, or vectorial forces having an impact on them in a flow of continuum. As these theories have been highly influenced by the ideas of scientific and philosophical figures such as D'Arcy Thompson, Kurt Gödel, Leibniz, and Gilles Deleuze, as well as Bergson's ideas in *Matter and Memory* (1911, 1927), Lynn defines animate form (Lynn, 1999) other than static/framed images of animations. Respectively, architecture primarily necessitates the virtual description of such realities that can no more be fixed at the Cartesian coordinate system (Lynn, 1999) by focusing on differential equations to generate topological forms.

The rise of curvilinearity and the coexisting rise of digital media have found critical inquiries on non-standard production in Lynn's studies. Non-standard production of the new industrial revolution, Industry 4.0, can be called according to the concept of Objectile by understanding The Fold (Carpo, 2014), in Deleuze's book, *The Fold, Leibniz and the Baroque* (Deleuze, 2006). Analysis of the dynamics of curvatures with their spatiotemporal as well as cultural values also refers to Bernard Cache's seminal concept of Objectile (Cache, 1995, p.20). There would not be any stable state for the 'technological' object, Objectile, whereas flows can describe it. Objectile moves in the continuum that requires the kinematics of such objects with their curvature on the planes of action. Hence, these revolutions can only be defined by the confluence of energies and fluxes in space-time by the movements of such objects[89].

The challenge, but also the opportunity that Objectile has brought, in that regard, is its timeless definition that without even direct reference to Industry 4.0 or the rise of the networked automation and production methods and human-computer interaction, Objectile, as a philosophical term, refers to the 'technological object'. The technological conditions also change and evolve together with the produced object through the environmental factors and the continuum of the flow of matter, information, energy, and production. Its accompanying entities, ensemble, and assemblies confer to an exact confluence of the states of fluctuating things as

[89] The only way that would be capable of assessing the conceptual existence of Objectile in the scales of space-time again corresponds to the necessity of analysis of non-linear systems (in entangled connections of this research).

theoretical keyframes. Therefore, Objectile itself indicates a continuous evolution of perpetually changing states that intervene in creative production.

Explaining the substantial role of non-standard production by the rise of computer-aided design and production in the revolution of Industry 4.0, Objectile is the best concept that should be considered from its authentic writer, Bernard Cache, when even regarding the recent parametric function of generation and production of complex forms and their creative action. The intervening agency of information in the generation and manipulation of that knowledge of production in space-time gets the responsibility of having the critical role in generating those states accordingly. Kolarevic reevaluates the closer relationship of information and the object, which refers to a new understanding in the production of non-standard objects that depend on the calculation of factors rather than leaving the aspects off into the risky decisions (Kolarevic, 2001; Kolarevic & Malkawi, 2005). So, in the definition of the existence and creation processes of Objectile, it defers to a complex action of emergence and motion. Furthermore, Objectile refers to the new understanding of things in the action and flow so that even the existing built environment and its entities can be identified as a part of informational progress to be assigned as proto-Objectiles grounding for new action of the described complexities.

Cache regards architectural image as an edifice and, respectively, as a method of the continuum of frames to depict the flow of actions and relations (Cache, 1995, p.21, 55). Thus, he tells the frame outside the elements as the point of relativity, as a mode of individuation between the two elements, by understanding the ternary topology's likely relations between the elements. Cache also mentions the Bergsonian point of view to be regarded through Affect, neuroscientific perspective, and psychology through the acting forces of externalities and environments over our bodies so that our sensorimotor processes become active in response to those actions (Cache, 1995). The association between different senses on the same stimuli corresponds to another changing and evolutionary set of states.

Since the different means of accessibility of objects to our senses vary, the accompanying relationships between our sensorimotor and cortical mechanisms, including visual and tactile senses, correspond to a non-linear complexity (Cache, 1995). Accordingly, the exact resolution of the perceived and imagined object necessitates a mirror stage that is to be defined by different sensorial, informational, knowledge bases. As this idea has already been determined by the seminal studies of Zak in the generation of self-image and conscious states (Zak, 2011), the complex condition can be understood in the existence of associative modalities and likelihood functions.

If there is a condition of other extremities and singularities that are hard to define rationally, it is here to propose first the analytical methods of entangled connections to model those complexities to dissolve those intricacies (Table 3.2). On one hand, such a collective intelligence[90] can be searched about those fluctuating changes in the commuting and discrete relations. These inquiries may not be linearly modeled but can only be considered as creative and yet discrete processes. These complexities can only be descried, then, with the help of the catastrophe theory. Regarding the catastrophe theory and the complexity that we deal with in the evolutionary trajectory of architecture, Cache notes the dynamics of space departing from the advanced studies into challenging domains such as the quantum field of gravity (Cache, 1995, p.46). He continues with how the catastrophe theory helps us to have relational modalities for abstractions about (bifurcation of) singularities (of surfaces, curvatures) through geometric intuitions as the possibilities of Subjectile regarding artistic creativity (Cache, 1995, pp. 48-51). Departing from the catastrophe theory and the singularities that are encountered within the scientific inquiries to understand the architectural references and domains, a basis for gauge can be clarified and concretized by the history of science and technology. Lynn explains the challenge of non-linearities with reference to the debut of the three-body problem, which was only ultimately solved in the first decade of the millennium:

> "In the three-body problem, however, time, or more properly duration and sequence, are integral to the spatial relationships being calculated. Another aspect of this kind of relationship, in which three or more objects interact, is that they often produce nonlinear behavior. The method by which these problems can be calculated is through mathematics that is sequential and continuous: thus the invention by both Newton and Leibniz of differential calculus." (Lynn, 1999).

John Frazer's studies on evolution and architecture (Frazer, 1995), on the other hand,

[90] As Perry & Hight (2006) have seminal inquiries in those complexities.

can be seen as the initial examples of attempts to find the gist of the common ground between biological evolution, the agenda of architecture, and informational technologies (Frazer, 1995; Menges & Ahlquist, 2011; Ahlquist & Menges, 2011). Frazer's approach finds its roots in the initial attempts of cybernetics, D'Arcy Thompson's inquiry in '*On Growth and Form'*, and Von Neumann's logic of cellular automata coming from biological inspirations. Conceptualizing the rules of nature by genetic coding and the evolutionary dynamics in evolution, John Frazer's seminal book *An Evolutionary Architecture* (Frazer, 1995) discusses the relationships about the nature of evolution [91] . Frazer, respectively, focused on the paradigm of evolutionary architecture, having been inspired from the form-generating basis of nature, especially biological Life and the genetic language of self-reproduction, growth, and morphogenesis in close relation to the informational basis. Accordingly, he has found a way to read the architectural concepts[92] and novel form-generation methods based on the logic between generative concepts of reproduction of biological life. As a code script for the creative steps in time that are to be replicated in the abstract logic of computation, the idea of genetic algorithms is genuinely described by Frazer with the inspiration from DNA structures (Frazer, 1995). This idea regards architectural production itself as an evolutionary and adaptive search and a systematic organism with direct connections to its environments and to other internal reference systems.

At this point, it is again crucial to turn to Lynn's arguments to remind us of the degree of complexity by which the computational technologies should face the rise of multiple references of science and culture. Lynn also critically analyzes Frazer's study and his logic of computation, and he suggests that the instrumentalization of nature's rules by computation should not miss the gist of nature as a challenge in itself. Lynn explains the distinct logic of topology, respectively, other than the nature-inspired algorithms of Frazer. From Lynn's perspective, then, in the running modes of machine intelligence as the simpler logic of genetic algorithms, it would not be enough to

[91] The emerging logic on algorithms have also been used in architectural inspirations that Terzidis's studies promote later to internalize non-human processes by systematic usage of scripting can be reported on the other side. (Terzidis, 2011).
[92] See also (Tschumi, 1994a; 1994b; 1994c; 2000; 2003; 2004; 2010; 2012).

consider them as creative and generative.

> "There are also some misconceptions about the role of computers in the design process. A precious few architectural designers and theorists, Karl Chu and John Frazer being the most lucid among them, argue for the creative capacity of computers to facilitate genetic design strategies. The genetic, or rule-based, phenomenon of computation should not be discounted. Yet at the same time, genetic processes should not be equated with either intelligence or nature." (Lynn, 1999)

Lynn grasps the internal logic of computation as being different from nature, and suggests considering it to be discretely other than the conventional means of design as a paradigm shift, as most of the significant factors are intricate topological entities. Therefore, even by referring to scientific roots and the logic of computation itself, this distinction in the interpretation of the digital paradigm reveals the emergence of initial bifurcations as contradictions in the second turn in architecture's creative evolution.

Current paradigms and influencing patterns of dynamic systems theory and genetics in architecture cannot be understood, though, as separate facts of professionalization, technology, and creativity. The fractal geometry of strange attractors that are arrested by new means of computation in their phase space is depending relatively on the initial conditions that also become the interests of the geometry of curvatures and their action-based conceptions in design, as Greg Lynn also seminally puts forth in *Animate Form* (Lynn, 1999). It needs to regard architects utilizing curvilinearity, topological geometry, morphology, and the catastrophe theory on the one hand, and the world's economic transformation with technological advancements and developments on the other. Architectural paradigms of the new logic and alternative studies of design that have flourished with the help of technological capabilities can be pursued in Lynn's essay (Lynn, 1993) on 'architectural curvilinearity'. His essay is one of the first examples of the new topological approach leading to the study of *Animate Form*. The elements of movement in a flow, to be frozen as a frame, are argued to be the reality of the animate form (Lynn, 1999). It can be similar to sensors that catch the kinetic motion generated again by the stream of dots as in Lynn's 'House Prototype' (Kolarevic, 2000). Hence, these approaches are not different from a scientific inquiry of fluid geometries, or from the Brownian movement of a microscopic particle, or Etienne-Jules Marey's project of a walking man clothed in black and white stripes (Lynn, 1999). These works would give solid grounds for further studies on 'Blob –

Binary Large Object' as well as on 'Embryologic Houses' of Lynn (Lynn, 2000: 26-35) as another stream of influential growth dealing with the complexity of shapes and curvatures. Additionally, topological geometry, parametricism, the modeling techniques of NURBS, and splines become a part of ephemerally 'creative' design processes in which the role of the Fold and the theme of 'Objectile' led thinkers such as Deleuze to claim the capacity of calculus to generate an infinite number of objects as elements of a continuous series.

Regarding the novel paradigmatic themes on Objectile in the new decades of 'the digital turn of architecture', new technologies become exclusively helpful according to Carpo, when even considering Hadid's car parking design (Carpo, 2013b). Carpo writes on this digital turn in the journal of '*Architectural Design'* exploring works since 1992 after Deconstructivism, as a cause to this turn that has been missed by the debate of Post-modernism (Carpo, 2013b). Especially having a conspicuous prominence on Greg Lynn's article of '*Architectural Curvilinearity*' (Lynn, 1993), leading the discussion further towards '*Nonlinear Architecture*', as written by Charles Jencks (1997a), the emerging paradigm is investigated by the generic issue of this journal. With respect to this issue, the need to read the digital paradigm in architecture in an evolutionary trajectory within and beyond the discrete attraction points and multiplicity of reference systems becomes clear. Hence, the paradigm can be reinforced with the expanding searches of architecture on organic nature with Frazer's debuting ideas by '*An Evolutionary Architecture'* (Frazer, 1995) and the discourse on cybernetics and information. On that point, it would be appropriate to claim that Charles Jencks's paper has even stronger signs of an evolving paradigm in architecture with the emerging fluid forms and the influence of fractal geometry in design through the influence of technology and the inspirational grounds of science. Based on the theories of chaos and complexities such as 'Catastrophe Theory' of the mathematician René Thom and the non-linear dynamics, the changes require the internalization of these developments for the new agenda of architecture's evolutionary profession.

By extending towards the prevailing dominance of large-scale production, the emergent paradigm of deconstructivists' attitudes also seemed to be transformed by the digital media as in Zaha Hadid's and her design partner Patrik Schumacher's designs as highly condensed with decorated ornamental forms. It even becomes possible to discuss the ‘mass customization’ of paradigms of the designers’ own agendas as in ‘Parametricism’ (Schumacher, 2011a; 2011b). This trend also shows the evolutionary change in the manner of Hadid from her deconstructivist style because her company has become the armada of the digital paradigm in architecture, exploiting the potentials of technology in search of the morphogenetic and, especially, the parametrized forms.

The perpetual presence of the Dutch figures that are near to the International Style, on the other hand, has also been evolving towards the emerging paradigm of the digital in architecture, strongly represented by Lars Spuybroek (Spuybroek, 1998) and Kas Oosterhuis in the early years of this turn. The changing influences of technology and concomitant theories from science (including the non-linear dynamics, chaos, complexity, fractals, and curvature geometries) have been reevaluated by the new logic of the digital media that has literally emerged as a search for the new agenda of architecture. *Architectural Design*’s sixty-eightieth issue, *Hypersurface Architecture*, introduces the twin water pavilions, Fresh Water, and Water Salt Pavilions with their Dutch designers leaning on the digital culture’s role in architecture (Carpo, 2013b).

The following years of the digital turn of architecture have also been celebrated with many other ‘experimental’ projects that range from the togetherness of the sensorial environments and traditional spaces to ordinary everyday life practices. The environmental concerns (Del Campo et al., 2013) of the rising threat of disasters, climate change, and the scarcity of resources (Snell, 2018) have profound inquiries for the design of the built environment. Similarly, ‘the maze and learning environments’ for the artificial agents as well as projects to synthesize the higher dimensions of spatial experiences of the everyday life practices by the dynamics of Life concern the fluids, thermodynamics, and the Living behavior (Beesley, 2013).

Ranging from formal (Hansmeyer, 2013) towards the logical confluences of design and computation (Sprecher, 2013), the dynamic forces of nature should be taken into consideration with the dimensionality of spatiotemporal and material experiences even as the self-organized bodies (Snooks, 2013). Schumacher also maintained to emphasize social and natural scientific inquiries on spatial and intellectual production in the definition of Autopoiesis (Schumacher, 2011a, 2011b). Thus, the complex systems of Life and society also influence social sciences of psychology or sociology that there should be certain concepts to be defined through non-linear dynamics. Even the initial approaches of Freud’s studies on scientific psychology correspond to such a field of inquiry (Freud, 2001). After decades, there could finally be found fruitful investigations with the rise of psychophysics and certain studies in neuroscience considering the non-linear dynamics, chaos, and complexity theories in psychological (Guastello, Koopmans & Pincus, 2009) and anatomical systems. It becomes clear that things are subject to external dynamics, even if they are stable and can be determined by linear principles. Thus, the dynamics of emotional affect (Beesley, 2013), and their all psychological-cognitive affects (Klein, 2013; Roche, 2013; Bressani, 2013), and their social dimensions by many experimental projects also majorly add up to the non-linear complexities with regard to the togetherness of Objectile and Subjectile.

Furthermore, by describing the first and second digital turn, even Mario Carpo (2013b; 2017) and Antoine Picon refer to the Renaissance’s impact and Vitruvius’s role in the history of classical architecture regarding the evolution of craftsmanship. Hansmeyer, for instance, generates a symbolic reference with regard to the five orders of the classical architectural columns representing the technology’s evolutionary basis enabling the production of the ‘sixth one’ in his art installation by the 3D constructions of ‘*The Sixth Order*’ (Figure 3.9).

Figure 3.9. 'The Sixth Order' (Hansmeyer, 2013)

In the new logic of computational design thinking and environmental aspects, Sprecher claims that effects and externalities recall the necessity to understand these relations of multiplicities and reference bases through multidisciplinary and intradisciplinary scenarios (Sprecher, 2013). The confluences of informational knowledge with architecture's edifices as well as its practice and theory are tied to referring to the convergent multiplicities in computational logic (just as in the case of von Neumann's confluence states). By the multiplicity of novel reference systems of scientific, mathematical, sociocultural, and ideological grassroots, it is possible to parametrize further experimental architecture projects under the forces of these externalities to simulate spatiotemporal practices perpetually just as referring to the true nature of the real 'emergence' of the matter in Life. Sprecher narrates: "…technology has exponentially increased its ability to add parameters, therefore producing models that are, too often idealistically, qualified as 'emergent'" (Sprecher, 2013).

Many significant figures have also studied the performativity of materiality, nature-based algorithms, and experiments on the nature of designing and manufacturing. For instance, Achim Menges occupies the productive side of architectural trajectory in the recent decade that only updates itself according to the rise of technology and scientific inquiries, especially on the biological and physical nature of things. Menges and Ahlquist have manifested the new perspective (agenda) to develop a new mode of creative thinking (Menges & Ahlquist, 2011) with respect to this fact. They propose to survey through the multiplicity of many fields as they even define this as the flow of multiplicities. This requires an understanding of the ecology of evolutionary bases and even nature itself with its evolutionary ecologies and Life forms to capture the experience of materiality as well as the confluence of different modes of thinking. This concern comprises system theory and cybernetics, with other inquiries ranging from morphogenesis to developmental biology, as well as mathematics, computer science, biology, and philosophy, to deal with the evolution itself (Bergson, 1998; Menges & Ahlquist, 2011, p. 8). However, this does not mean that computation should be regarded as the prevailing instrumentalization of computerization and mechanization but should internalize the natural way of computation regarding the evolutionary and genetic algorithms or the generative complexities of nature with its power of combination.

Finding the non-linear causalities, in that regard, can only be explained by the theory of complexities such as the catastrophe theory or the second law of thermodynamics to be indicated by “Far from Equilibrium Theory” (Menges & Ahlquist, 2011). The intricate relationship of creativity in design and the emerging paradigms of genetic and evolutionary algorithms and genetic programming indicate intellectual grounds. Bentley and Corne, in their book of *Creative Evolutionary Systems (2002),* analyze the natural kernels of reproduction, growth, and evolution from embryology to phenotype representation to be handled with the components of the new industrial conditions (Bentley & Corne, 2011; Menges & Ahlquist, 2011), which are significant when considered with the ideas from Bergson’s book, *Creative Evolution*.

Focusing on the generative concepts of new design thinking, evolutionary computation, morphogenesis, and the population of evolutionary systems are especially welcomed as the major topics of the evolving paradigm by the mathematical iterations and the logic of computation. The complexities to be broken down into necessary mathematical iterations are also argued by D’Arcy Thompson, mentioning about Henri Poincaré’s revolutionary manifesto on the science of nature (of things) to conceptualize his approach on *Growth and Form* by a multidisciplinary approach from biology, physics, and mathematics (D’Arcy Thompson, 1917). Accordingly, even creativity is regarded as a mode of algorithmic design that explains the creative leap through the decision-making models and the multiplicity of functions (sigmoid, tanh) and jumps in between, described in *Creative Confluence* (Hoorn, 2014).

The grasped differences in the paradigm shift of the digital in architecture can be described as the instrumentalization of the rules of nature, as the differences in interpreting space-time with its materiality, and the applying forces that generate the intricate bifurcations, *per se*. They are **the modes of intelligence** ranging from material to subjective, natural, and social; artificial, and even environmental intelligence that require elaborating the degrees of complexities when regarding the challenges that even current computational technologies cannot merely overcome in linearity. There have also been even laborious and assiduous attempts to optimize the human-computer interaction focusing on intelligence models such as ‘*The Intradata Computer*’. Kwinter tries to put forth this as a fallacy of computation (Kwinter, 2011): Computation should not be regarded as instrumental computerization discarding nature’s own ability toward combinatory creativity. Thus, evolution requires a permutational increase of computational time for the artificial agents that become a real challenge for computational science by the 'NP-complete problem'. Kwinter tries to signify a similar point of view by saying:

> "No computer on earth can match the processing power of even the most simple natural system, be it of water molecules on a warm rock, a rudimentary enzyme system, or the movement of leaves in the wind. The most powerful and challenging use of the computer (aside from the obvious benefits of automated number crunching in purely numerical domains such as accounting) is in learning how to make a simple organization (the computer) model what is intrinsic about a more complex, infinitely entailed organization (the natural or real system)." (Kwinter, 2011; Menges & Ahlquist, 2011)

Hence, the complexity of intelligence is also argued again under the non-linear dynamics of nature to be abstracted through mathematics and logical iterations. Computational technologies' endeavors should adopt and overcome the tangible form of computation by considering the chaos, complexity, and self-organization in nature by investigating natural intelligence and modes of creativity that nature effectively does beyond the reductive representations into semantics and syntax. Thus, the study surveys abstract models regarding unsolved challenging problems, like NP-complete, turbulence, Riemann zeta function, or Navier-Stokes problems, for modes of organizations with spatiotemporal practices and optimization problems (Connes & Marcolli, 2008; Ivancevic & Ivancevic, 2012; Zak, 2013; 2014; Yang et al., 2020). In exploring the novelties of each aspect of design, production, and conduction as cognitive and behavioral research, these endeavors are thought to lead to new paradigms.

Finally, by reading the first and second turns together, the new modes of interaction may generate new paradigms and fields of knowledge. Regarding the future of the non-standard production and the relations of flows in correlation or confluence with Subjectile by such technological developments and scientific endeavor, the necessity of imagination and creativity reveals the new forms of intelligence from non-linear complexities. In that regard, it is even possible to put forth the different novel theorizations of Discrete Architectures (Retsin, 2019) as well as Non-Discrete Architectures in the continuum (Leach, 2019) concerning the production, construction as well as the perception of spatiotemporalities and acting external forces in architecture throughout. These distinctions strongly imply the fledgling bifurcations of theories/paradigms and modalities; and indicate the novel relations between Objectile and Subjectile of human-artificial correlation in environmental aspects and in the near future of 'Robotic Building(s)'. Nevertheless, even the generic and prodigal paradigm shifts cannot be seen as sufficient to consider the reality of scientific roots and the role of the innovative endeavor of architectural technology without considering the role of smart spaces and the future of Industry 5.0 in the integration with the dynamics of creativity with socio-economic and performative responsibilities.

In short, the recent faint oppositions of the new modalities of the Discrete and the Continuum reveal profound philosophical argumentations with propositions of *Difference and Repetition* (Deleuze, 2004) that can be read together by *Creative Evolution* (Bergson, 1998). Nevertheless, they necessitate the role of creativity in the co-existences with innovative technologies and complexities of 'creative evolution' that are supposed to be considered in critical argumentations.

3.3. Explorations for a Third Paradigmatic Turn

The evolutionary progress in architecture under the influences of diverse domains is explored through references and examples defined via industrial dynamics and the theme of creative evolution. These reference systems also indicate the significant repercussions of collective intelligence to be consolidated with informational studies and technologies. At this point, the study argues that the endeavor of creative subjects, their organizational aspects, and spatiotemporal acts may reindicate the ultimate role of universities and campus environments as the spatiotemporalities in the generation of collective informational knowledge, science, and technology. Besides their educational, cultural, and collective roles, it is believed that university environments can be discussed with the importance of freedom of imagination and creativity in human-technology relations, and they can generate novel paradigmatic relations even if they are not significantly discussed in the literature of the second paradigmatic turn.

The roles and abstract models of creativity, in that regard, can be surveyed and developed together with the unexplored potentials of universities to find connections for novel paradigmatic turns. This exercise can also be a part of the creative reasoning of this research on the studied examples and reference systems (Table 3.4). In that regard, the university campuses are selected to be evaluated to increase the significance of the discourse on the spatiotemporal environments and organizational formations. This chapter claims that collective forms of creative subjects in architecture have strong traces to follow certain bifurcating lines of practice and production of information with new technologies to be tested in the built environment.

In the development of smart built environments, creativity necessitates more sensorial inputs. This would also relate to the challenging practices and organizational forms of creativity, and further to the consolidating form of architectonic practices in the rise of smart spaces. Hence, this part tries to find non-linear modalities and methodologies for complexities in the creative organization of networked actors for new contemplations of spatial practices. The question is how novel and creative architectonic and architectural organizations can be achieved by regarding evolutionary technology, manufacturing, design, and Objectile in the built environment.

There are divergent and convergent 'culminating' points (Bergson, 1998) between the evolutionary transformation of the modern culture and the (post-)information basis of research and knowledge of novel paradigms in architecture (Table 3.4). Hence, the divergent attraction points among those multiplicities make us cogitate a larger domain of confluences that describes the condition of architecture as an evolutionary profession. This mentioned proposition includes the geospatial locations and urban environments that we inhabit from the very early ages and the cultural transformation of the built environment, including the wide-ranging duration from the first to the fourth, and towards the fifth, industrial revolutions. The confluences of the places we live in and the technological endeavor in architectural technology indicate the futuristic togetherness of culture of creativity and scientific bases of innovation. The role of universities in creating such togetherness as a learning experience can also be regarded as another relevant question to be studied.

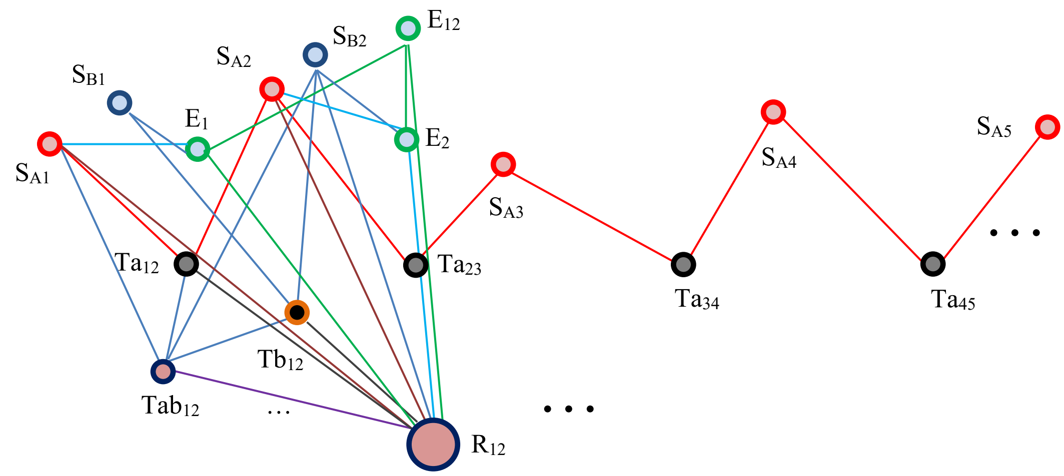
These propositions necessitate the new modalities in architecture. Regarding the role of new computational technologies and accompanying advanced algorithms and methods to discover the challenging non-linearities, this part of the study suggests some hypothetical solutions to the possible interaction of different reference systems at a larger scale. In that regard, possible circumstances between the future of creative subjects and architectural technology should be looked at the abstract, mathematical, cognitive, computational models, geometrical reflections, and organizational models of creativity to be tested in the built environment. On the other hand, the repercussions on spatiotemporalities and architectural environments can only be proposed to be followed once again at the very tactical scale so as to generate attraction points to control non-linearities and topological complexities through technology-human-nature relations as topologies. The larger-scale repercussions of such spatiotemporal experiences should also integrate creativity in the organizational formations of the individuals. University campuses can be seen as such intricate spatiotemporalities to interpret new learning experiences.

The rising impact and influences of smart spaces, robotics in construction, and human-computer interactions imply new architectural technology and its innovative engineering by practice and production (Vasey & Menges, 2020). Further advancements in science and technology and the role of creativity in architecture in the information age are expected to meet the ground truth of new epistemologies. Those common grounds are expected to generate novel exceptions and means of recognition, organizations, and realization of different means of architectural and spatiotemporal intelligence via creativity. Respectively, the chapter gives precedent examples of how creative endeavor can be integrated with the external forces of the built environment concerning the organization of architectural spaces and accompanying creative and collective organizations. The study aims to reveal individual creative works with the interconnection of the forces of the built environment. This aims to determine the faint projections towards the creative and smart spatial attractors by rising influences of learning environments, new means of computation, and construction. Consequently, this part pursues to present abstract models for the rising information-intense and cognitive tasks and interactions of architects regarding creativity. The study further dwells on how organizational complexities can be re-understood by creative organization models and factors of design, manufacturing, and technology. Finally, it looks for the primary examples of creativity for spatiotemporal attractors of architectonic qualities that are believed to imply the future of their strategic design to be implied in the development of intelligent built environments (Table 3.4).

Abstract/Cognitive Models for Creativity and Learning in Non-linearities: The place of creativity and learning has paramount importance in the dynamics of non-linearities and new technologies, such as neuromorphic computing, to analyze behavioral patterns and knowledge construction. An essential start to the discussion of the construction of knowledge and its recurrent reconstruction is to remember the architecture with its prior conditions. On the other hand, for the common ground between artificial, informational, and subjective models in the generation of cognitive ensembles of knowledge, it would be appropriate to recall the types of learning: unsupervised, semi-supervised, supervised, and reinforced (Rao & Fairhall, 2017-2020a; 2017-2020b; Brunton, & Kutz, 2019). The conditioned information of the given knowledge about the designed environments (with fewer uncertainties or more informed/guided processes) can be seen as a part of reinforced or supervised learning (Rao & Fairhall, 2017-2020a; 2017-2020b).

The binary notation (like 0's and 1's and in-between values) for the complex relations of the states of architectural and spatiotemporal activities can only be discovered by using certain constraints over the function of each relation. However, such classical approaches may have weaknesses relating to those constraints and given values without exactly representing the complexities for each state, and indeed may need advanced decision-making models (Ebrahimigharehbaghi et al., 2021). Thus, it would not be possible to understand creativity and the non-linear relations that are described in dynamic system theories by classical models in challenging decision making in architecture. The question of how abstract models of technology can help to substantialize the cultural collectivity and creativity in human-computer-environment interaction at such complexity becomes an inquiry of this research (Table 3.3). Regarding the topology of the togetherness of human-artificial and natural environments, it is crucial to consider challenging issues of action of probability to find out the correlation between the respectively discrete, independent events (Wichert, 2014) (Appendix B). The condition of universities can also be regarded at such a level of complexity. This inquiry also corresponds to a search for collective mind to be generated again from the precedent discussions and their concomitant theoretical and spatiotemporal references in dynamic evolution (Table 3.3).

Table 3.3. Entangled Connection with perpetually increasing references/interactions



Collective mind with modes of creativity, conscience, and intelligence (or reference of the informational ground truth for affective computing), processing the collective and emotional states of heterogeneous multiplicities, can be modeled with reference to subject-environment interactions and their correlations with the artificial. The filtered elements of cognition in creating information constitute the entities for the reconstruction of knowledge. This modeling is supposed to be reinforced with sensor values, processed with motion energy filters, various spatiotemporal filtering, and the compounds for non-linearity to take an action of the experience in its temporality for knowledge creation. Knowledge-information-knowledge conversion (and even their ecologies) is far more complex than the suggested path of the cognitive models, which may become naïve and rudimentary to understand the higher energy levels, the entropy of information of datasets, a series of states, and the interrelated representational relations. In this respect, further insights into the information, its theory as well as the construction and reconstruction of knowledge would further be implied and suggested.

Methodologies, Organizational models, and Scientific inquiries of Learning for Non-linearities with Reconsideration of the creative production-knowledge: It is here that we should search for some basis of organizational aspects of creativity

(Feldman, 1999) to relate the multiplicity of knowledge and reference systems with the agency of creativity that coexists with the built environment. The book *Creative Confluence* has a relatively closer approach: the writer of the book, Johan F. Hoorn, shares an anecdote to imagine the methods of how conceptually similar elements can be classified and regressed, and how performative action can generate a creative organization via appropriate methods (Hoorn, 2014). Hoorn describes the difficulties of unitary formation of distinct and discrete things if they cannot directly correspond to each other as a challenge of non-linear dynamics that call for complexity models. This question may even leave the ground to discuss mathematical or informational models corresponding to similar (rational) studies as in Herbert Simon's inquiries on management models (Simon, 1960) and in *Sciences of the Artificial* (Simon, 1995; 1996). By describing the emergence of novel theories on the second law of thermodynamics, fractal geometries (Mandelbrot, 2001), neurosciences, and complicated computer modeling, he marks the necessity of creativity to be understood in the complexity of non-linearities (Hoorn, 2014) (Figure 3.10).

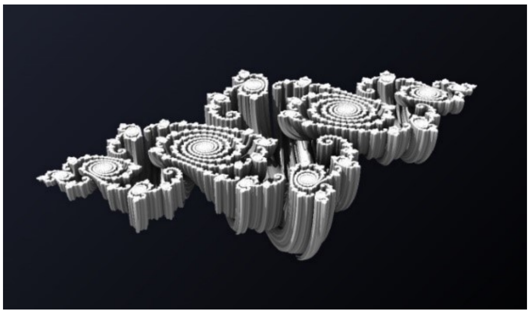


Figure 3.10. 3D sculpture derived from Mandelbrot fractals

For this inquiry, Hoorn introduces the concept of confluence (Hoorn, 2014). Accordingly, confluences should include conjunctions and disjunctions, or 'convergences' and 'divergences' among different lineages of approaches, processes, references by their common points, and the aspects of what make them distinguishable in a mode of complex togetherness. In the age of quantum theories, these creative leaps can be understood by their informational trajectory through discrete creation processes (Bergson, 1998, pp. 251-271; Hoorn, 2014). Even though the intricacies, uncertainties (Heisenberg, 1966), and the underdetermination of complexities describe a non-linear process, it is just those complexities that make us think differently even in imagining the future of quantum computers integrated with the built environment, such as universities.

Regarding the emotional and social levels of interaction of subjectivities, there are additional factors to be focused on, which actually make modeling those intricacies even more difficult. Nevertheless, Hoorn has an agenda that is full of methods and models to simulate those intricacies under the concepts of creative leaps, similar to Bergson's conceptions, and confluences of those trajectories (Bergson, 1998; Hoorn, 2014). Hoorn attempts to find out some elements and entities to be processed as operative structures of modeling that would be based on a generative mindset (Hoorn, 2014)[93]. Hoorn constructs this modeling as a hierarchical complexity of brain functions starting with autonomous control for survival activities towards processes of instinct, memory, language, intelligence (Ballard, 2015), and, finally, creativity that is oriented to opportunities (with discrete as well as continuous aspects) (Hoorn, 2014).

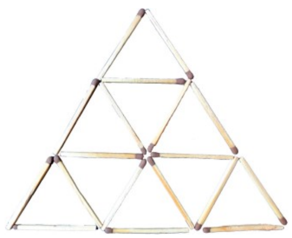
By adopting an essential perspective, the logical structure seems legitimate regarding the hierarchical abstraction of those cognitive levels, even as computational/informational entities (Ballard, 2015) with certain entropies. However, regarding the information and feature processing of the entities logically, Hoorn's attempt can be seen as similar to the algorithmic structure of neural networks with feedforward and feedback mechanisms. As a matter of problem solving, then, creativity and intelligence are seen as reciprocal modalities to work together with the activity of long-term and short-term memory concerning the desired state of action and result (Hoorn, 2014). Thus, while intelligence understands the elements and converges to those processes' learned contexts, creativity does single the divergent novelties out. Hoorn declares that informational models, based on statistical facts, can barely return a completely new/creative state (Hoorn, 2014). He also admits the challenge that any of those probabilistic models, rather than fully deterministic ones, can only help to point out the creative 'possibilities' compared to Life's complexity.

There can be many varieties of those models, including game theory and social decision theory, even within the conceptual schema of those cognitive levels.

[93] -by utilizing the possibilities of inspiring rules of quantum mechanics with the lattice structures of solids (Heisenberg, 1966), and defining the membership of subjective factors as the sets of a fuzzy logic.

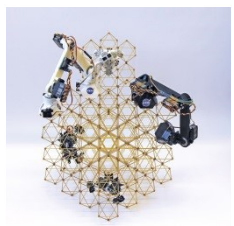
Accordingly, intelligence works as a model that can first converge and then diverge the features to come up with some solution spaces, and creativity can first diverge and then converge or synthesize informational facts or even physical entities (Hoorn, 2014). The uncanny relationship between the first and the second paradigmatic turns, for instance, can be seen as a generative domain of knowledge-based relations. This inaccessible condition of divergences can become a part of the creative executions for the upcoming Industrial revolutions as well as the corresponding space-time conceptions when they are re-iterated by the search over the common grounds of science and technology. This generative knowledge domain would also correspond to the necessary role of imagination and creativity in the critical role of collectivity for the evolutionary mindset of architecture.

When dealing with the fuzzy relations of entities, the processes of creativity, association, combination, abstraction, selection, integration, and adaptation are also proposed as operative concepts (Hoorn, 2014). However, such models again propose the associative relations among the entities, their features, and data that are facilitated through those decision-making systems. Recombinatory mechanisms, correlations, and likelihood occurrences may help to redescribe the complexity of these modalities[94]. Those modalities are also crucial to envision the novel paradigms (Table 3.4) that are evolved from the more straightforward forms of intelligence towards creative executions. These also orient our efforts towards the radical dexterity of artificial agencies in each step of creative thought, design, action, and production as in the future of intelligent spaces and human-artificial interactions (Figure 3.11).



Model that mode of intelligence generates

Model that creativity modifies (Hoorn, 2014)



A physical model that robots construct (Retsin, 2019)

Figure 3.11. Evolutionary Creativity in the Logic of Model Construction

[94] The problem can even be mathematically modeled by Traveling Salesman Problem. Then, the fringes of those possibilities can be optimized through artificial intelligence regarding the likelihood functions.

To explain the complexity of the brain cells' natural phenomena when encountering new stimuli as the source of creative behavior, Hoorn explains the common systematic mechanism from cognitive neuroscience and computational decision making (Hoorn, 2014). There are also more in-depth insights into the brain's non-linear dynamics and cell structure (Izhikevich, 2007). Such models are consequential to estimate the futuristic role of the neuromorphic computational chips and even their place in the challenges of built environments. For the organizational scale, Hoorn iterates decision making as a creative process ranging from 'Transaction Processing System' to 'Strategic Management' (Hoorn, 2014) (Figure 3.12). Accordingly, each member of state with combinatorial probabilities and parameters of social-cultural or economic interactions and preferences can be sorted out as a map of values and entities. Such relations can be constructed with the help of some functional and methodic conventions among those fuzzy sets (Figure 3.12) (Zimmermann, 2010; Hoorn, 2014).

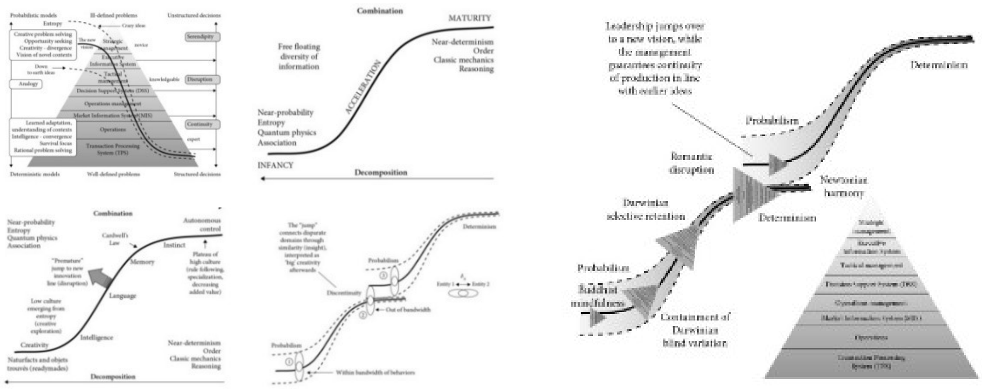


Figure 3.12. An evolutionary proposal of modeling (of) creativity at the organizational level by Hoorn. Images and charts from Hoorn (2014)

Accordingly, each creative leap that Hoorn proposes at the management level of those complexities (Hoorn, 2014) will generate novel progresses. Then, reading those curves and the data landscapes would give us clues about the learning processes as well as novelties of creative leaps/jumps; and even adaptation of those processes to other contexts, evolving towards a coherent togetherness that is subjected to another creative jump (Appendix B). There can also be found conditions indicating the multiple/interacting forces/elements and attractors. The necessary step then is to regard the creativity with spatiotemporalities with regard to certain experimental studies that can be seen as attractors points (Zak, 2011; Ivancevic & Ivancevic, 2012) in the built environment. Universities and research institutes, for instance, have paramount importance as spatiotemporal and organizational bodies to be discussed with the scientific and technological improvements (Table 3.4). Even though the discourse in the second confluential turn on this finding is limited, Silicon Valley or Boston Route 128 are the generator places for most of the informational technologies, housing significant research universities, R&D centers, and start-up companies.

Spatiotemporal Attractors of Confluences: Klex, Hylozoic Series, *Architecture of Humeurs*: Regarding the rise of sensorial learning environments with the necessity of creativity, smart spatial attractors can be implied with a few exceptional precedent spatiotemporal and tectonic examples. Ruy Klein, for instance, describes one of the most interesting and sole examples based on the true nature of the interaction of the psychological dynamics of subjects with the form-based fractalized shapes in the *Klex* project. In this project, Klein refers to a student working to measure psychological dispositions in 1921 (Figure 3.13) (Klein, 2013).

It is not strange to introduce here matter-form-substance conversions as the simulative experimentations of architecture. Philip Beesley gives one of the more extraordinary and unique attempts to realize how the different aspects of physical forces can be designed in his art installation[95], *Hylozoic Series* (2012), as spatiotemporal attractors (Beesley, 2013). With many innovative components assessing thermodynamic effects, the fluids on a coherent body of formal construction, that is made of the inspirational quantum form of 'the lattice structure of subatomic particles'[96], configure and interact through the formation of 'Hylozoic chevron diagrid system'. The system is made of protocells with inorganic materials that are capable of movement, replication, evolution, and even self-assembly (Beesley, 2013), yet reacts to its environmental forces in the manner of an artificial information system with its embedded microprocessor (Figure 3.13).

[95] See also (Ascott, 2006) in the analysis of many experimental projects that try to understand the common logic between the biotic and abiotic creatures through avant-garde and innovative art studies, installations, even simpler robotics, and their systems of artificial intelligence by the artificial as well as biological systems and their dynamics.
[96] See also (Kruşa Yemişçioğlu, Sorguç, & Özgenel, 2018).

Figure 3.13. Klex, by Ruy Klein (Klein, 2013) (Left); Hylozoic Series, Beesley, 2012 (Right)

Hence, further complex systematic unity requires an intelligent system that can have an artificial logic, which does provide the mutant togetherness of the artificial and natural bodies in a coherent whole. Such an inquiry is encountered in François Roche's works, *Viab02*, or the so-called 'an architecture of *humeurs*' (Roche, 2013). The project, having the ability to process the confluential fluids of dopamine, hydrocortisone, melatonin, and adrenaline, proposes an 'acephalous body' by that new artificial logic of signaling and mimicking the emotional states and changes of bodies (Roche, 2013). Based on the factors ranging from biochemical to neurobiological as well as psychological and mood-related effects and desires, the artificial rationality behind the mathematical set theory can again facilitate those dynamics in a bodily reaction of the machinic posture under the external forces. Such a machinic innovation, then, can be evaluated as a coherent bodily attractor of those implying forces that are processed again by a distinct logic of signaling with reference to and yet beyond the subjective idiosyncrasies and singularities (Figure 3.14).

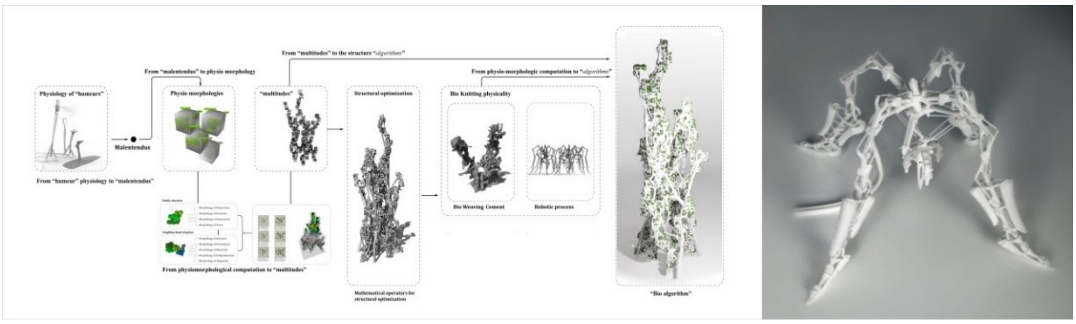


Figure 3.14. An architecture of humeurs (left), Viab02 (right) by Roche (Roche, 2013)

Further social and psychological dimensions of such interactions are studied in MONAD Studio's Wolfsonian Satellite Pavilion (Goldemberg et al., 2013). The project works to catch the movement of cars, pedestrians, the collective actions and interactions, other environmental factors, and even social, cultural, political traces on the environment and the city (Goldemberg et al., 2013). The building works as a 'social thermometer' through its designed capacitors, as spatial attractors, to measure those effects for urban computing and to check whether the relations are correlational or not (Goldemberg et al., 2013). MONAD Studio explains the Lincoln Road project with its challenging circumstances to measure the confluential dynamics as a "dynamic entanglement of public events with an energy that can only be described as vibrant, funky, and sensual" (Goldemberg et al., 2013).

Regarding all these examples, the integration of technological advancements in larger-scale urban environments can further be developed together with the generation of informational knowledge and spatiotemporal action. In that regard, it is significant to remember the collective role of university environments as unique findings to be interpreted with spatiotemporal attractor designs under the influence of scientific, technological, and natural campus environments.

3.4. Concluding Remarks

Creative Evolution genuinely dates back to Henri Bergson's book of the same name (1907, 1911), exploring the phenomenology of the discrete things that give birth to the actual dynamics of Life in evolution per se (Bergson, 1998). With this governing idea about the relations between humans, technology, and nature, *Creative Evolution* can be chronologically situated among the advancements and 'culminating points' in modern science in physics, biology, and life sciences (Bergson, 1998, pp. 329-344) during the mature era of Industry 1.0 and in the rise of Industry 2.0. In that regard, published in 1907 in French and 1911 in English, *Creative Evolution* can be bespoken just at the verge of the emerging ideas about the empirical relations of life sciences that are coeval to the rise of the modern profession of architecture. Accordingly, this modality can also be seen as the multiple existences of evolutionary trajectories and discrete entities that are tried to be explored in this chapter.

Respectively, multiple paradigms with the discrete or correlational models and relations between human-artificial agent interactions are regarded as themes (for informational bases) to be argued by creative evolution as a form of intelligence in this research. Describing the co-existence of multiple, and yet distinct research and evolutionary trajectories in architectural practice and theory also has a methodologically distinct place in this thesis. Primarily, even distinguished studies, such as D'Arcy Thompson's metamorphosis (1917) and von Neumann's automata studies in the 1950s, which implies the rise of the information theory and Industry 3.0, can be discussed with regard to their impacts on architecture.

The heterotopic condition of Industry 4.0 towards Industry 5.0, on the other hand, can enable us to generate creative steps between the imagination and emergence, thought and action, when regarding the future of intelligent spaces. This potential suggests a return to the emergence of things and their material experience as an aesthetic phenomenon in spatial production. It directs our efforts to the changes in the modes and relations of production of capitalism influencing humankind's direct interaction with its environment and including property relations, his/her sense-perception, and its cognitive and aesthetic meanings[97].

The future of Industry 5.0 and Objectile with fuzzy and complex relations may also propose some utopian landscapes of practice in correlation with the new technologies of neuromorphic chips, quantum processors, and new molecular computing possibilities. Just at this point, Sorkin orients his critiques toward the possibilities of mental architecture as a 'dream' having the universal product of thought and knowledge on architecture, yet to be downloaded on a mere silicon chip showing the confluential dystopia for the built environment (Sorkin, 2015; 2019). Nevertheless, it is evident that the components of imagination are much more necessary than the pre-agricultural urban settlements of hunters and gatherers when regarding the urbanization of the built environment. Thus, in the age of advanced technology, humankind is much closer ever to the immediate realization of the utopia(s) through the help of new technologies, which are also used to emphasize the multiplicity of

[97] Objectile, as the technology that flows produced by capitalism can also become a political tool for the control of architectural environments, and the sense perceptions of the inhabitants.

subjectivities with imagination.

In the existence of these confluences, the role of imagination and creativity necessitates a critical consciousness about the role of collectivity in production and spatiotemporal experiences[98]. The social interpretations in the design of the Free University of Berlin, for instance, remind one of how social and cultural dynamics, as well as the changing industrial and paradigmatic relations, ought to be re-evaluated with imagination and collective experiences together. Spatiotemporal imagination of utopia can be a creative way to escape from the heterotopic world of confluences as a far-from-equilibrium condition. In contrast, the ultimate meaning of utopia other than such dynamic interpretation corresponds to the ultimate equilibrium of nature, an end in itself, as in the balance in the third law of thermodynamics.

With respect to this, there should be the creative interplay of multiplicities of flows/agents that facilitate the ultimate utopia between Objectile and Subjectile. Briefly, the derived spatiotemporal knowledge of experiences in confluences can be diagnosed with slight alterations, *per se*. This evolving ground corresponds to far-from-equilibrium condition(s), the condition of contradistinction of dynamic evolution (Mayr, 2011) as the dynamic changes in the defined states of action, the evolutionary togetherness of the flow of energies[99].

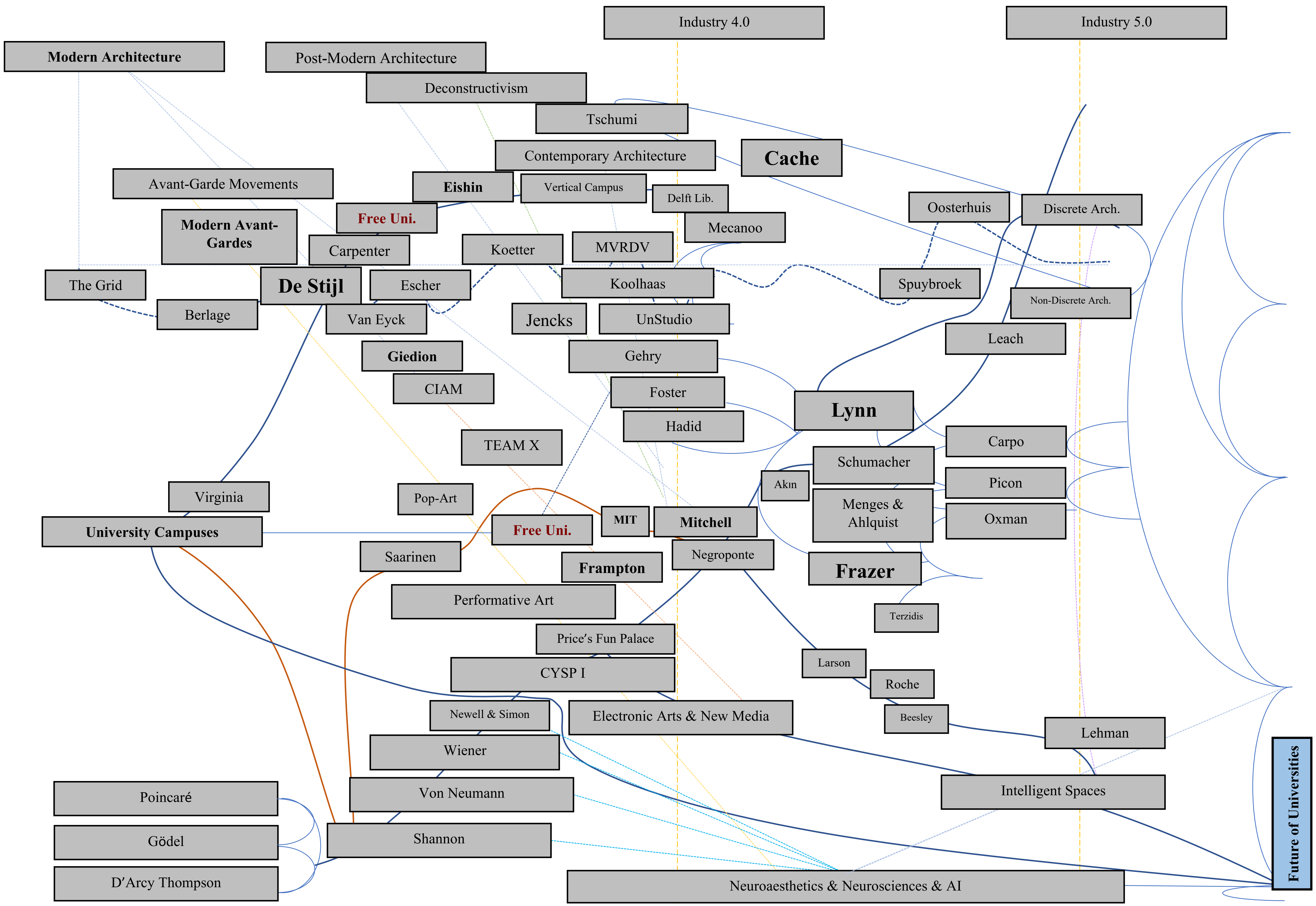
Hence, the togetherness of two distinct confluential paradigms in architecture may describe the multiplicity of different reference systems (and actors). Respectively, a creative mapping through those references is produced to regard novel and creative interplays for evolutionary paradigms (Table 3.4). The dynamics of creativity and the perpetual transformation of technology, 'intelligent environments', and production relations of human-artificial interaction/correlation evoke different entities and modalities to determine non-linearities and singularities for advancements in the built environment. The potentials of the intelligent environments and their corresponding

[98] The relation between the ideal and real enables to understand the utopia and the reality of space (Tafuri, 1976; 1987). The discourse of university finds its meaning, respectively, in the particular understanding of space-time experience.

[99] Motion, and of evolution in the energy fields that are to be discovered in modern times had been left as a mystery, for example by Boltzmann as one of the pioneers of the scientific paradigm on the motion of particular things at the end of his postulation of motion and energy (Boltzmann, 1974) for the further discovery. The evolution of the states from energies, as a slight contradistinction in far-from-equilibrium condition, in this respect, is concomitant with a germane analysis of energies and identities of those concerned paradigm shifts.

research fields in cognitive, informational, and science-based domains reveal undefined and yet creative relations with the organizational and spatiotemporal aspects of universities and technological advancements. Thus, the closer proximity and relations between the emerging research fields like neuroscience, neuroaesthetics, and new generation computing means with their influences in the academic environments can be reinvestigated further, and their architectural reflections can clearly reveal projections for novel epistemological shifts and creative paradigmatic relations within Industry 5.0 (Table 3.4). With the research on the creative interplay among the dynamic balances of various reference systems regarding cognitive, organizational, and spatiotemporal aspects, the study asks: 'Can university spaces be places to inspect the evolutionary change from Industry 4.0 to 5.0?'. In that regard, the study implies universities' future as the grounds for other developments like intelligent spaces regarding the organization of the creative subjects and the transformation of production, technology, and science parallel to industrial revolutions and the architectural mainstreams in evolution.

Table 3.4. Mapping Entangled Connections between the References and Examples of the Third Chapter



CHAPTER 4

MODALITIES AND MODULATIONS OF EVOLUTIONARY ARCHITECTURE IN INDUSTRY 4.0

Inspired by Bergson's key concepts of duration and motion on relations and order of matter, body, and cognitive aspects, this chapter aims to conceptualize the current tendencies as well as the discussed interrelations of humans, technologies, nature, and the built environment in architecture. Henri Bergson's conceptual arguments in *Creative Evolution*, as in many of his books, discuss the key concepts of duration for describing the emergence and being of morphogenetic materiality in nature, and the concept of motion and becoming for a change in action in this durational time regarding applying forces and fluxes (Bergson, 1998, pp. 1-11; 298-314). This chapter aims to analyze and cluster the examples and technological paradigms of architecture accordingly into related sub-classes of these themes under the circumstances of Industry 4.0 (Table 4.5), as a method of intelligence suggested by Hoorn (Hoorn, 2014). This conceptual analysis initially relates the very early influences of industrial revolutions towards constructing relations and modalities between Subjectile-Objectile and the built environment, and modulations of technological paradigms and experimental works in architecture. This approach enables us to read the experiences of the built environment of our everyday life and current technological evolutions together under the selected concepts.

Evaluating intelligence and creativity together through selected key themes, the methodology also distinguishes the different manners in similar periods. For instance, even two very distinct approaches of Frazer and Lynn, or the distinctions either in their creative 'Discreteness' or 'Continuum' in human-artificial interactions and intelligent spaces, are seen as entirely coherent in their own rights yet to be scrutinized separately in creative evolution. To be mentioned in the same direction of the proposed 'modulations', evolutionary trajectories of interdisciplinary and multidisciplinary approaches in architecture are further explored.

Therefore, these 'modulations' are primarily based on the theoretical concepts from Bergson's Creative Evolution to distinguish first (1) the things in their morphogenetic and substantial emergences in 'duration'; and (2) the change of this duration through action and time-perception in relation to 'motion' (or succession) (Bergson, 1998, pp. 1-11; 298-314). The rising complexities in human-computer interaction and the emerging research fields that are reflected in architecture like bioinformatics, genetic algorithms, and swarm intelligence, on the other hand, require further synthetic conceptualizations. In that sense, the third classification investigates (3) the synthetic conceptuality between duration and motion, as a creative method (Hoorn, 2014), by specifically dwelling on the key themes of bioinformatics and swarm intelligence. This classification also complements the evolutionary concepts for the challenging uncertainty (Heisenberg, 1966) and 'experience' in space-time to identify creative and synthetic scientific/disciplinary discoveries/trajectories in biology and physics that are also necessarily significant in Bergson's *Creative Evolution* (Bergson, 1998, pp. 29-36). Even the instrumentalizations of biologically inspired or topologically complex formations correspond to a coherent agenda of thought and evolutionary practice, *per se*. Thus, this inquiry will help to understand new relations between humans, technology, and the environment by finding intersections between scientific and technological modalities in the evolutionary profession of architecture.

Architecture's relation with science (Di Cristina, 2001; Ponte, 2013; Ito, 2016) has also become apparent in the discourse on space-time (Picon, 2003a; 2003b; 2003c). Many academic and practicing architects from Giedion (2008) to Tschumi (1994a) have prioritized the theme of experience with the discourse on space-time. The understanding of space-time, then, has varied from the pure reasoning on the aesthetics towards its heterogeneity (Hensel, Hight & Menges, 2009a; 2009b; Hensel & Menges, 2009). The conceptual evolution of space-time is directly reflected in the discourse and practice of architecture, ranging from spatial constructivism to Hausmann's creative destruction in modernity (Harvey, 1989). The critical epochs in architecture's creative evolution can also be extended from the rise of deconstructivism to the new paradigm of digital architecture focusing on the limits of Euclidean space, Riemann curvatures, and the non-Euclidean geometry of Minkovskian space. In the early 1990s, some leading figures, such as Greg Lynn, staked out claims on the complex curvatures, non-linear geometries, and non-standard production towards Industry 4.0 (Lynn, 1993; 1999). To get the relationship of non-linearity[100] and the complex integrity of subject's body and behavior to the dynamical environments of Life, the togetherness of object, subject, and the environment is further considered as the coalescence of the material and external forces by 'entanglements' in architecture (Hensel, Hight, Menges, 2009a). Thus, scientific discourses envision 'ecologies' of the bodily activities of subjects interacting with the artificial and natural environments through their energy-related dynamics (Hensel, Hight, & Menges, 2009a; 2009b).

To explain how scientific research, technology, and production in Objectile, Subjectile, and environmental relations in architecture are interpreted in this research according to these selected concepts, it may be helpful to return to the basic principles of evolution in the dynamics of natural forces and scientific concepts. The second law in Newtonian mechanics and thermodynamics describes a dynamic flow, as states of deterritorialization from one state to another towards the equilibrium[101] that are determined through their 'durations' and 'motions' (Akhundov, 1986). These concepts of duration and motion are also in the same order of the modern philosophy[102], and they are also relevant to the industrial transformation by the development of the steam engine since it has been used in the scientific measurements of the essential principles of nature, determined later as the three principles of thermodynamics (AnaBritannica, 1988). Hence, these principles are also related to the mechanical dynamics of motion and relevant in describing the evolution of things with respect to the classical forces in nature (Akhundov, 1986), which have affected the modern discourse heavily. The emergence of the steam engine, in that regard, is not only significant in terms of revealing the very first industrial revolution, **Industry 1.0**, but also in terms of

[100] The idea of non-linearity seems to be adopted by the philosophers such as Deleuze, accrediting the Fold geometry and Leibniz's monadology (Leibniz, 2005; Deleuze, 2004; 2006). It is also possible to encounter the significant emphasis on Riemann curvature in Einstein's and Poincare's studies in the transformation of epistemological perspectives in science and mathematics of space-time analyzed by architect-writers (Rosenfeld, 1988; Poincare, 1913; 1962; Hensel, Hight and Menges, 2009).
[101] according to the first as well as the third principles of mechanics or thermodynamics
[102] See also (Kant, 1922; Akhundov, 1986).

identifying the rise of industrialization and urbanization, and the increasing dichotomy between urban and rural like the duality of Gesellschaft versus Gemeinschaft (Frampton, 2007).

Multiple arguments of space-time in the culture of architecture and the order of city in the conceptually complementary modalities and types of relations can also be understood, then, as the complex and evolutionary togetherness of those durations and motions in their 'heterogeneous states' in phase/solution space. However, that heterogeneity generates a challenge to measure each distinct state of things in space-time for that of the classical and modern science of Newtonian mechanics and thermodynamics. It was until Einstein, who postulated General and Special Relativity, that he revealed a skeptical perspective on the uncertainty of those measurements as a challenging problem, inspected later by quantum physics and mechanics (Einstein, 2001; AnaBritannica, 1988). Concomitantly, the discovery of the electromagnetic forces has led to electricity usage via this scientific progress, celebrating the birth of **Industry 2.0**, implying the rise of mass production and modernism. This progress in science would explain how the measurement of things can be empirically possible (with their motion/speed and their static states/properties) other than analyzing the volume, mass, and trajectories of celestial bodies.

Following the duration and motion in this chapter, the intersecting relations between bioinformatics and swarm intelligence have been interpreted to understand the challenge of measuring things on their scientific grounds in architecture[103]. Regarding the role of the scientific inquiries about architectural environments once again, we can encounter the seminal citations to the scientific figures and their ideas of the following period, such as Erwin Schrödinger. Even though his ideas barely appear in the literature of architecture, Schrödinger's novel understanding of space, together with the rise of information theories, are told through the concepts of Homeostasis and Entropy by Christopher Hight (2009). The scientific philosophy, evaluating the observer's relativity that cannot separate itself from the dynamics of Life, has best been described by Schrödinger's study of '*What is Life?*' (Schrödinger, 1944; 1992;

[103] Based on the scientific explorations of the Parallax View (Žižek, 2006), the uncertainty principle puts forth how the identical energy sources with different locations and mechanical dynamics can be measured only as a probability (Heisenberg, 1953; 1966; Feynman, 1961; 1963; 1985; 1995; 2005; 2011a; 2011b; 2006).

2010)[104].

His contributions are also significant in terms of pinpointing humanity's novel relationship with its 'collective intelligence' concerning entropy, information, and the order of things in Life's equity by referring to his surprising concept of 'negentropy'[105]. Simply influenced by Reyner Banham's ideas focusing on the collective behavior of ancient people gathering around the fire, in '*The Architecture of Well-Tempered Environment*' (Banham, 1969; 2009), Christopher Hight also refers to Schrödinger. Thus, Hight's approach to thermodynamics and Entropy seems to have the key concepts focusing on the counterbalance of Entropy and Negentropy by Homeostasis (Hight, 2009). So, it is possible to explain spatiotemporal experiences of the homeostatic balance of bodies in response to the external forces of Life by referring to Schrödinger[106].

In the coeval period, other scientific and technological inquiries like von Neumann's and Shannon's studies on entropy (von Neumann, 1956, 1958; Shannon, 1949, 1956) focused on the common nature (and its forces) of things and the evolutionary nature of biological as well as other physical, artificial things. Based on the scientific inquiries, such studies can even date back to Boltzmann's studies with an inquiry that re-evaluates the mechanical principles of motion with thermodynamics (Boltzmann, 1975). These findings have also led to the rise of the statistical mechanics commonly used in quantum physics and with the concepts of entropy and thermodynamic energy of things (Nakahara & Tanaka, 2013), with their biological, Life-based traces. Those findings are crucial in the emergence of 'the science of information'[107] (Shannon, 1949; 1956; Avery, 2012) that is evaluated in the automata mechanisms that are based on the physical principles; and yet have mimicked the biological behavior of the human brain/mind (Hebb, 1949; von Neumann, 1958). These studies have also given

[104] Schrödinger's ideas also contributed to the probabilistic nature of quantum physics through the paradox of Schrödinger's cat (Nielsen & Chuang, 2010). According to this theory, it is impossible to know a state beforehand or exactly what it had without direct observation, but there can only be possibilities.

[105] Negentropy is the negativity of entropy of things that can be defined with the free energy in a closed system (of Life) as complicated quantum mechanical concept developed by Edwin Schrödinger. See also (Azuma, & Subramanian, 2018; Hight, 2009, p. 163).

[106] Schrödinger's studies are also fruitful for some of the Nobel laureates that even enabled the everyday life practices in medicine, genetics as well as in some engineering studies.

[107] Information is also defined as the determination of uncertainty, which actually increases once the entropy increases. See also (Shannon, 1949, 1956; Bekenstein, 2003; Avery, 2012; Scales, 2012; Wilde, 2013; Sawerwain, 2017).

rise to 'information theories' and to 'automation' based on the investigation of the artificial logic of the machinery inspired by the human mind's basic behavior, leading to the revolution of **Industry 3.0**. After the futurists' initial attempts, like Cedric Price or Negroponte, as trying to give the initial and yet rare examples of the logic of 'automation' in architecture in the 1970s, these studies are crucial to understanding the dynamics in artificial intelligence in their customized usages with biologically-inspired algorithms in architecture. Informational grounds in bioinformatics and swarm intelligence, in that regard, are thought to overcome those scientific challenges to measure the state of things with their durational states, qualities, and properties, together with their motion states and the dynamics. The related discussions also locate the place of the information theory and cybernetics in architecture by grasping Wiener's and von Neumann's seminal studies (Picon, 2010) and shared theories on the evolutionary algorithms regarding new relations between Subjectile-Objectile and the environment.

At this point, it is crucial to return to Cache's evaluation of space-time conceptions by elaborating the subjectivity and continuum between Subjectile and the non-standard produced object, Objectile, through the mirror stage (Cache, 1995; Deleuze, 2004; 2006; Leibniz, 2005). In the book *Earth Moves*, Cache turns his attention to grasp the history of handmade non-linear surfaces, as the products or casings of Subjectile for production and manufacturing of objects evolved towards non-standard production of *Computer-Assisted Conception and Fabrication* (CFAO) systems that are apparent in **Industry 4.0**. In the rise of artificial intelligence, Subjectile as a surface/interface of subject(ivity) with regard to high-technological produced volumetric object, Objectile, can be seen as still evolved and has turned into the training of neural networks about the subject's outcomes and products, and the crowdsourcing of actions and preferences. This new mode of interaction, once again, is thought to generate non-standard data of new/virtual planes of mirror stages for consumption, production, representation, modeling, function, and marketing by parametrized variables of choices, preferences (Cache, 1995), and even subjective productions; in short, the new Subjectile.

Thus, this study's concern is to include and classify the modalities of subject-technology-environment relations through literature-based, scientific, technological, cognitive, spatiotemporal, and even epistemological findings clustered as conceptual modulations. Respectively, this chapter comprises three sub-chapters. The spatiotemporal relations of architect-subject, technology, and environment are to be analyzed **first** in relation to the emergence of things in space-time under **the theme of duration**. The related themes of evolution, morphogenesis, or emergence are such concepts that can dissolve most of the concepts. Thus, the narration on duration focuses on the form-generation and its material qualities as merged into one category of research in the rise of non-standard production of **Industry 4.0**. The implications of this sub-chapter orient the study towards form-based generation; and the emergence of things regarding their cognitive, property-based relations and the rise of new technological and scientific inquiries. The study further continues with the new interfaces of human-computer interaction and maintains the research over the novel means of correlations between humans and technology. Environmental relations and sensorial aspects regarding Objectile and Subjectile interactions will also be investigated through new forms of technologies and the logic for human-computer interaction to multiply and conceptualize the examples in the rise of Industry 4.0. The new possibilities of actual production are also investigated to develop abstract/conceptual, cultural, and critical arguments. Then, this inquiry meets the analyses of larger organizational and collective scales, as the concept corresponds to well-established philosophy and culture in the history of modernity and the relational research on mind, matter, and identity.

The theme of motion, respectively, signifies the scientific thought of spatiotemporalities whence there are only determined forces and vectors applying to the entities as objects and identities as if they are contingent on instant materiality. Thus, **the second sub-chapter** analyzes those modalities of space-time in action; and the corresponding paradigms, especially in recent decades, to be seen as representing the rise of the new computational technologies generating the new endeavor of research and practice in architecture. In this part, the cognitive and organizational grounds are investigated according to the built environment's corresponding transformations. The inquiry starts from the spaces that generate movement or the architectonics that really move or interfere with motion forces. Then, the discussion progresses towards the cultural and spatial milieu of this development, like intelligent spaces and sites of high technology to develop organizational models of interactions.

As the synthetic and effective way of regarding the classical, Euclidean, and Minkovskian spaces together, **the themes of bioinformatics and swarm intelligence** regard the problem of uncertainty by grasping the materiality and the motion forces and vectors together. Accordingly, **the third subchapter** can be evaluated with the synthetic modalities of the first and the second sub-chapters, and actually has the potential to outline the futuristic possibilities and research that are present in science and technology. Finally, the chapter discusses the challenges of the built environment together with the action of its agencies and the condition of the creative subject under the influence of new paradigms. Accordingly, this part rehandles the condition of architecture, the built environment, and its natural, artificial, and human agencies together in an analytical perspective of the current and emerging paradigms under the lights of collective intelligence and their abstract and creative modalities.

4.1. Duration and Emergence

4.1.1. Introduction

Duration is a unique term emphasized by Henri Bergson throughout most of his concepts on evolution (Bergson, 1911; 1998, pp. 1-11), cognitive interpretations, absolute and empirical space-time theories. The theorization of the materialization of space-time in the 20th century, depending on the concept of duration as matter in space, has even grounded for the recent scientific debates on the theories of the mechanism of cosmic inflation, or how dark matter can be explained (AnaBritannica, 1988; Bergson, 1998; Becker, Becker & Schwartz, 2007; Cappiello, Ng, & Beacom, 2019). Accordingly, the substantialization of things with their form is analyzed in different paradigms of geometries and mathematics. Their production and reproduction are also analyzed through the theories of nature and evolution that are relevant to thermodynamics in the emergence, ecologies, and adaptation of things with their energies/entropies.

The concept of ‘duration’ or ‘emergence’, accordingly, not only describes an ontological viewpoint to grasp this abstract thinking, it also relates to the coherent historical materiality of architecture and the evolutionary process of Industrial Revolutions. Thus, architecture’s relation to precedent revolutions can be discussed with the built environment we live in through Modernity’s paradigms[108]. These modalities can also be evaluated by the concepts of Objectile and Subjectile in the Industry 4.0 conditions. Thus, it is to look at Objectile and Subjectile by the ontological question of the emergence of things to regard their togetherness at intersecting durations first other than their fluxes.

These discussions are also crucial to introduce the necessary ways of thinking and perception for state-of-the-art technologies. With the rise of the recent technological developments in Industry 4.0, it even becomes possible to talk about the fruitful research and production processes at the nanoscale (envisioning the growth of new molecular computing and synthetic biology) regarding things as filling the space with their peculiar features and properties as quanta ‘for/with information’. In architecture, the condition is not indeed distinct from what we define for the science of physics or astronomy or the theories on space-time. The matter in space is a determining concept (AnaBritannica, 1988), and the most significant inquiry of architectural production is based on the materiality and tectonics of things with their strength and durability.

Inspirational grounds of genetic and evolutionary algorithms at the intersection of informational studies correspond to the profound inquiries on the emergence and properties of things in their coherent form of matter as substantial durations in time. Thus, it is apparent to dwell on what John Frazer has brought by the seminal discussions on evolutionary architecture depending on the inspiring grounds of biology (Frazer, 1995) and geometry concerning the concept of emergence. Emergence within the literature of evolutionary biology (Bergson, 1998, pp. 168-169) and chemical physics is critical to classify certain non-linear relations and complexities. Regarding the territorialization of the Objectile that resides in thought and practice, it becomes very crucial to define the things with their identities under the definition of their natural properties, such as their morphogenetic form. The book

[108] -including most of the references from modernism, post-modernism, and deconstructivist examples.

Emergence (Hensel, Menges, & Weinstock, 2004) can thus be introduced as the first systematic inquiry in architecture on the same concept to reveal the interconnections between the sciences on nature and evolution and the rising digital paradigm of information technologies.

Emergence also has inquiries and questions on the nature of things with the similar questions of the nineteenth century and even relation with artificial dynamics in the inquiry of intelligence. Relatively, evolution and morphogenesis are the key terms regarding the artificial evolution of architecture with form-based and nature-inspired conceptualizations. Emergence integrates the abstract sense of form and geometry with the material qualities of production when considering the complexity of duration (Bergson, 1998, pp. 199-220) in real-life dynamics by developmental biology, physical chemistry, and mathematics. John Holland's article, *Emergence from Chaos to Order* (Hensel, Menges, & Weinstock, 2004; Holland, 2011), has described best the unitary concept of emergence that can be (re)constructed from the confluences of chaotic complexities. The mathematical basis, similarly, bridges the discussion of emergence and morphogenetic design in architecture (Weinstock, 2004).

At the intersection of technology, information systems, and mathematics on the natural emergence of things, complex forms and systems are explored through advancing techniques of artificial intelligence. The flexible modes of organizations all generate the dynamics of an ecological system of "topological, structural and programmatic integration of human activities" (Hight, Hensel, Menges, 2009). The inquiry on the emergence of material qualities and their experimental action-based parametrization with their performative nature have primarily alternated the production through tectonic inquiries in architecture. The physical and material characteristics in the advancement of fabrication and material performance as well as the behavioral patterns, environmental modulations, and material systems, and the integration of design techniques and manufacturing are explored with the rise of Industry 4.0 through artificial intelligence towards the potentials of new technologies. Furthermore, the integration of the scientific inquiries of thermodynamics offers research beyond mere form-finding tools of material and structural performance, including inquiries of other sensorial and infrastructural capabilities, efficiencies, and dynamics.

Ranging from cognitive aspects of geometry and form in the emergence of things to their substantialization processes through design and practice from the macro- to the nanoscale, the emergent discussion on the digital paradigm of informational theories can also be founded in the interplay between human-computer interactions and in the rise of Digital Twins. For that reason, the discrete emergences of creative processes by subjects and artificial agents have significant places for the decomposition of design, production, and interfacing relations. Architecture's relation with Industry 4.0 also puts forth the changing interfaces for Industry 5.0 between how the subject and artificial agents interact (Özkezer, 2018; Rada, 2019). Both the subject and technology play key roles in the 'creative shifts' of evolutionary professionalization and the emergence of architectural things. Hence, the generative position of artificial interfaces of design and architecture becomes one of the major concerns of the study. For instance, William Mitchell formally constructs architectural design's referential basis through the very early computational interface in *The Logic of Architecture* at the turn of artificial intelligence. The book's logic comprises the sets of architectural culture and the construction of an artificial logic of computation together (Mitchell, 1994) as a predicate to the ancient, diagrammatic, and practically modern building type by defining elements, properties, their linguistic and logical compounds.

Further analyses on informational modalities and interactions between humans, technology, and the environment through space-time concepts of duration and the emergence of things comprise 'possibilities' of digital interfaces between the actual and virtual. The subject's role in Subjectile-Objectile interfaces in architectural design and practicing narrows down the study; and makes it possible to focus on the role of the recent technological revolutions. Similarly, duration and emergence can be read as a developmental process of architectural materiality by the relations of design, construction, and the technological interfaces, just as in the case of Sagrada Familia extending from the very first form-finding experiments of Gaudy to Burry's digital documentation of (re)construction of the church (Burry, 2013).

Architecture also indicates its initial conflicts and necessities of modernistic knowledge and practice as a profession in the information age: Territorialization and deterritorialization as critical terms help to scrutinize the cognitive and spatiotemporal organizational complexities of the boundaries of the subject-environment-technology topologies of creative architect-subject and architectural technology. Accordingly, the evolutionary phases of professionalization correspond to the problem of territorialization that calls for substantial relations of cognitive, spatiotemporal, organizational, and epistemological elements in the aspects of adaptation. This evolution identifies the restructuring processes of capitalism in the (re)organization of workforce and services throughout the flow of transportation, money, goods, commodities, and information (Spencer, 2016). Accordingly, it is to explore the facts that the experiences of the new capitalist production (and services) reveal the evolutionary change in space-time perception. It is to argue that the new interactive interfaces and new modes of spatial reorganization (of time-space compression/expansion), in that sense, also influence architectural transformation as an evolutionary professionalization under the forces of the global capital.

4.1.2. Rising Research on Emergence, Evolutionary Geometry, Computational Logic, and New Technologies in Architecture

The concept of emergence and morphogenesis can be analyzed for how the physical explorations of complex geometries are unified as substantialization iterated by mathematical conventions of imaginary capacities (Weinstock, 2011). Emergence can be evaluated through the correlational studies of evolutionary biology, artificial intelligence (and the genetic and evolutionary algorithms in between), complexity theory, cybernetics, and general systems theory. The theme of 'evolution' with the concept of 'emergence' corresponds to a process examined from Darwin's to D'Arcy Thompson's inquiries on the growth and morphogenetic form in evolution when compared to Whitehead's geometrical analyses (Whitehead, 1971a; 1971b). Thus, the digital paradigm in architecture regards the liberation of tectonics from orthogonal geometry by the capability in complex geometries and theoretical interchange of ideas between biology, physical chemistry, and mathematics. The behavior of material form has also appeared as complex, non-linear, and context specific.

The geometry and morphogenesis of things are first explained by their inherent nature that appears or emerges as such, and even inspires the mathematical models of communication such as Turing's, Shannon's as well as von Neumann's computational models by the common inquiries on biology, mathematics, and physical space-time. Through mathematics and biology, the intricate behavior is rehandled by Wiener's theory on 'cybernetics' developing responsive behavior in machines (Picon, 2010). The inquiries on the geometry and form of things, besides material and organizational behavior, have ranged from D'Arcy Thompson's inquiries and Mandelbrot's fractals to Frazer's seminal work on architecture and evolution. This progress also lasts towards the emergence of genetic and evolutionary algorithms as well as the early usage of artificial intelligence in architecture by Negroponte and Mitchell.

The emergence of Gaudi's innovative search of form about monumental solids and cavities, Buckminster Fuller's geodesic domes, and Frei Otto's tensile structures and membranes supported by the grid shells have initiated that innovative culture with the rise of technological advances in design and manufacturing. Furthermore, with the rise of digital media, the inquiry into morphogenesis enabled the creative integration of form-finding that turns into the 'emergence' of Objectile as the flowing design and production processes (Hensel, Menges, Weinstock, 2004) as 'discrete durations' (Bergson, 1998). This creative theme also corresponds to the coexistence of correlational procedures like the informational complexity of digital twins, including the concepts of evolution and self-organization of material form and Objectile.

Paradigm shifts in the science of geometry have reflected the technological development in the recent decades of computational design. The emergence of non-Euclidean Geometry with reference to Euclidean postulations is the most distinct inference to this evolutionary growth of the knowledge field (Lorenzo-Eiroa, Sprecher, 2013; Menges & Ahlquist, 2011) (Appendix C). Thus, architects must know geometry and its intricate relationships that limit or entail the possible design solutions (Williams, 2013) via rising informational technologies. By exploring the features of three-dimensional geometry to get the differential geometry, the evolutionary path to 'relativity'[109] gives essence to reveal the knowledge of spatiotemporal experience through geometrical references of complex thinking.

[109] See also (Russell, 2009).

Complex mathematical expressions indicate the interfaces of informational media. However, architects may not be able to distinguish the predetermined parameters of those software whether the parameters change the shape or size of the curve; they can solely control either the 'increase in height per revolution' or simply the radius itself (Williams, 2013). This distinction is very similar to the critical thought in the emergence of non-Euclidean Geometries as an evolutionary path in science. It is a critical inflection point that architects should recognize sitting in front of the virtual media because layering multidimensional information surpasses the coordinates of three-dimensional coordinate space.

New problems of architecture in the authorization of the script stand as another paradox. The general critique focuses on having an implicit set of predetermined rules of standard visualization of representational space or non-determined usages of formal representations. Notwithstanding these, topology claims the alternative ways of overcoming these rigidities, broadening the geometrical/functional possibilities beyond the predetermination of linear functional structures (Lorenzo-Eiroa, 2013). The evolutionary history from Euclidean Geometry to non-Euclidean Geometry (Rosenfeld, 1988) signifies these alternative solutions to an indifferent problem that both keeps the Euclidean and non-Euclidean solutions of geometrical spaces in Hilbert Space (Appendix C). The shift from basic shapes to the topology of a building is found in the parametric modeling of dependent variables. Branko Kolarevic defines the potentials of parametric design by emphasizing the creativity to deal with much more profound complex, curvilinear forms by the shift to topology (Kolarevic, 2013) and non-Euclidean geometry alternating the principles of Cartesian logic (Appendix C).

The geometrical configurations of things and feature-based identities can also be identified with the thermodynamics laws regarding the duration of things in nature. The strong relation between the geometrical formation and the physical features of elements of nature and theoretical studies has inspired many manufacturing projects and assembly of structures as in *Material Equilibria* (Peters & Peters, 2013; Young, 2013) (Figure 4.1). The joint research between morphogenesis, thermodynamic systems, metabolisms, and their reflections on the architectural and spatial experimentations are also studied with possible potentials of molecular computing and the new logical basis of artificial intelligence in the unique search of *Neo-plasmatic Design* (Cruz & Pike, 2008) (Figure 4.2). The design of molecular, computer-like systems enables developing a shared basis between the artificial logic of computation and the tectonics between nature and its corresponding artificial models. It requires understanding the dynamics of osmotic pressure, thermodynamics, and other non-linear environmental forces that apply to the natural agencies (Figure 4.2).

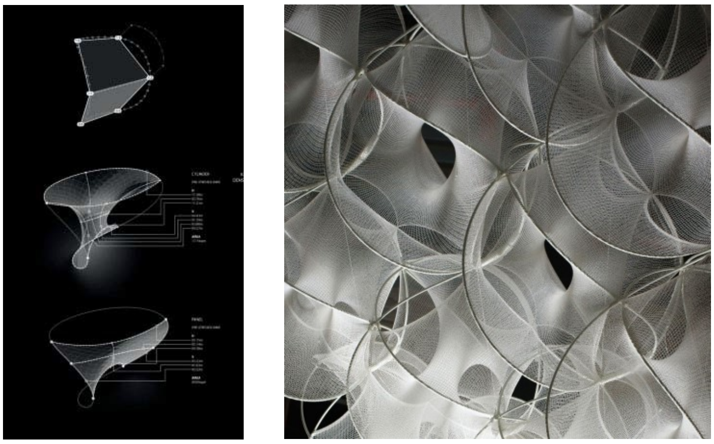
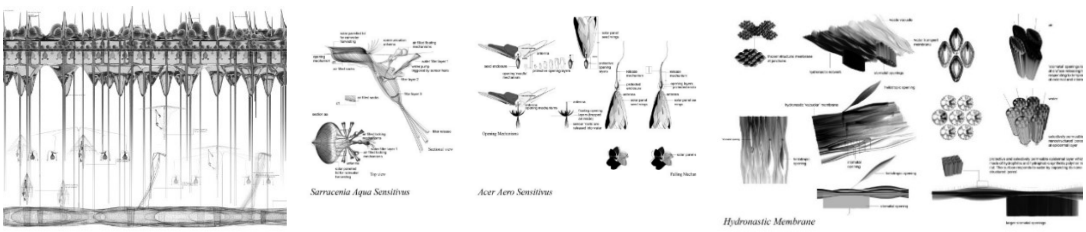


Figure 4.1. Sean Ahlquist, Bum Suk Ko, and Achim Menges, Material Equilibria Variegated surface structures, gallery, Copenhagen, 2012 (Steele, 2013; Eiroa et al., 2013)



(1) (2) (3)

Figure 4.2. (1) The skin and the micro-machinery (Cellular Growth Enhancement by White, 2003-04) (2008); (2) Homeostasis in Architecture (Christiansen, 2008, p. 11); (3) Hydronastic Membrane (Ala-Jaaski, 2008) from (Cruz, M., & Pike, S., 2008)

With regard to the research on synthetic biological systems, control engineering, evolutionary algorithms, and Gene Regulatory Networks (GRN) using RNN (Palafox, Noman, Iba, 2013; Noman, Palafox, Iba, 2013; Iba & Noman, 2016) (Figure 4.3), it is significant to understand this substantial basis of new computation technologies by the scientific research understanding nanotechnology and nanosystems in architecture. The entanglement(s) between technology, nature, and design can also be analyzed through the relations of information, new interfaces, and interdisciplinarities like neural networks for natural computing (Suzuki, 2013). Nanotechnological research also enables understanding the future of 4D printing with the self-organization of those molecular, chemical reactions (Tibbits et al., 2017); and the generation of other creative agencies envisioning the future of natural and molecular computing and evolution towards the future of Quantum computing and AI (Wichert, 2014).

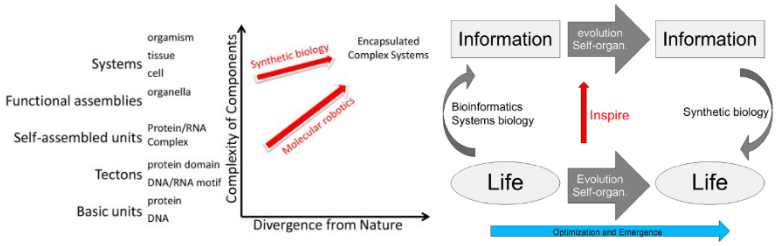


Figure 4.3. Comparison of Synthetic Biology and Molecular Robotics and Evolutionary cycles between the Life and Information (Suzuki & Nakagaki, 2013)

It is also possible to discuss the common nature of things with energies, entropies, and information-related properties through positional feature-based topologies and quantum systems of lattice structures as the matrices of electrons. Jenny Sabin's projects of *Fourier Transform* (2005) and *Fourier Carpet* (2006) (Figure 4.4) are related studies in design that exploit matrix structures of quantum-related feature-based lattices for measured transformations, based on the quantum-based methods and operations (Sabin, 2013). Sabin insists on the production of weaved colors of wool in the design of carpet through the binary logic that is constructed through mathematical and trigonometric relations by more complex Fourier series and by the methods of transformation of physical forces, open life systems, and feature-based properties.

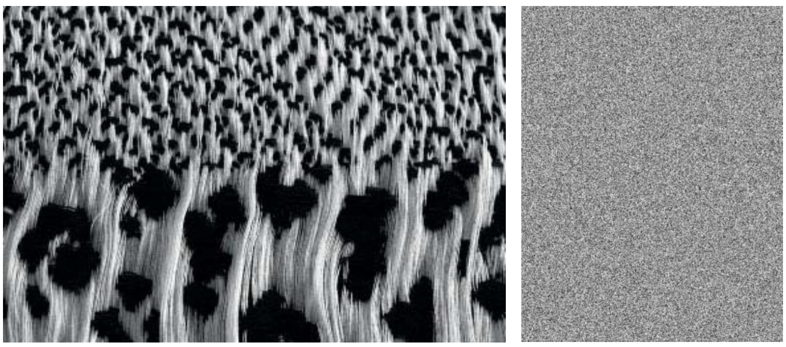


Figure 4.4. Fourier Carpet (Sabin, 2013) (Left); Quantum Gray, 2014, (Morel; 2019) (Right)

Similarly, the surface code that is theorized via spin glass as a ‘bridge between quantum systems and statistical mechanics’, in another project, is analyzed as an intricate informational ground (Nakahara & Tanaka, 2013; Ohzeki, 2013). Optimization of the best probable lineage of the quantum systems among various dynamics can be reinforced with Philip Morel’s study in his work of ‘Quantum Gray’ (2014) (Morel, 2019) with its perceptual quality in duration. The work can be seen as gray from a far distance, yet the whole internal composition reveals a far-from-equilibrium state among the black and white hues (Figure 4.4).

Moreover, the relation of design with Constructal Law can also be put forth because “design is the constructal path to persist in time (to survival). Each system acquires configuration (design) in time, by replacing an existing configuration by a design.” (Bejan, 2016). Accordingly, “for any flow system, there is a property as configuration” and “flow occurs against resistances (imperfections) that constantly try to slow down.” (Bejan, 2016). The design of walls, for instance, can integrate topological and involutional ‘non-Euclidean’ geometries when designed according to the theories on ‘Maxwell’s Demon’ (Nielsen & Chuang, 2010) by focusing on the changing climatic conditions. This idea manifests a challenging proposal, just like running an automated self-sufficient air conditioner with materials’ morphogenetic design. The place of the Constructal Law in design[110] (Rocha, Lorente, Bejan, 2013; Bejan, 2016) from those principles and concepts gives way to think further on the transformative capacities of things in duration from their form and geometries. When regarding the common basis between the natural and artificial, the scientific investigations can even extend towards the new inquiries of molecular computing or some innovative/entropy-related applications in scientific inquiries (such as vacuum wall) (Kallipoliti & Tsamis, 2013; Young; 2013) (Figure 4.5) by the rules of the second law of thermodynamics.

4.1.3. Evolutionary Ecologies of Digital Production and Adaptive Environment(s)

The evolution of informational technologies via manufacturing against the loss of

[110] Constructal Law is seminally discussed by (Bejan, 2016) in the analysis of evolutionary dynamics of the second law of thermodynamics in relation to entropy and duration to describe the emergence of things.

connection with the material also offers new fields of research in architecture. The emergence of polymers and microelectronics (Drexler, 1992; 2013) and the search for fusion in electropolymeric films and electroactive "micromuscles" can be seen as new materiality. They can enable the programmable bio-responsive feedback loops and nanoscale switches (Zhang, 2021) in the endeavor to increase the self-sufficient behavior of materials regarding creative architectural technologies. Hence, nanoparticles are to be seen via the practical implementation of 'self-assembly systems', enabling the creation of substantialization of cultivated data through physical, molecular, mechanical, and other forms of energy research. Nanosystems can also be evaluated as a creative inquiry on the formation of novel productive and synthetic systematic growth, including molecular machinery and novel computational processing (including quantum systems) and manufacturing.

The features of emergences within and outside architecture coexist with creative and discrete durations that reveal environmental parameters indicating the material and structural 'performances' (Kolarevic, 2015). Morphological patterns can be regarded as interactive ecologies of connectivity and closure (Hensel et al., 2004). The external forces that apply to the morphogenetic form of things and structures have additional parameters as the transmission of light and energy, local illumination, temperature gradient, air movement; and they reveal themselves in the 'non-linear relations' that are interacted through a membrane and dead-air chambers (Hensel et al., 2004). On the other hand, the issues in biomimetics to understand the nature and the behavior of fibers and membrane structures and their compounds (Drexler, 1992; Suzuki, 2013; Reichert, Menges, Correa Zuluaga, 2014) can be developed as synthetic scientific models. These models even help to understand the osmotic pressure that can be used to model new means of computation (molecular, synthetic biology) regarding the dynamics of negentropy and even entropy-based entanglements in fuzzy environments and atomically precise manufacturing (APM) (Song, 2013; Drexler, 2013).

Regarding the performative aspects of materiality, density, capacity, and the properties of things in nature, the same logic of duration and parameters are developed in very different scales. The external factors of air, energy (of the sun), and thermodynamics are also under the consideration of those ecological interactions. Integration of environmental concerns such as ventilation, the flood of air conditioning, or solar energy (Raman, Li, Fan, 2019; Deppe & Munday, 2020) is also considered in another research through morphogenetic inquiries of the intersection of form and matter at the tectonic scale (Alkadri, Luca, D., Turrin, & Sarıyıldız, 2020). This can be investigated as in the case of building envelope designs by the inspirational natural forces, which are still popular when considering such morphogenetic evolutionary formations, again revealing the abstract reflection of DNA coding as the inherited source of emergence, evolution, and morphogenesis.

The provision of complex topologies with natural evolutionary identities and properties like a living membrane encapsulates the essence of an analytical inquiry. The investigation recently shows itself off in the reflections of 4D printing, including the challenge of environmental forces, action, and motion of the material with the concern of the emergence of things with their identities and properties (Tibbits, 2014); that correspond to a natural process of duration in the adaptation to environments (Bergson, 1998, pp. 101-105) (Figure 4.5). Similarly, the self-assembly and evolutionary construction of the molecular assemblies in the concern of design and morphogenesis should be regarded as geometrical and behavioral, and functional topologies (Figure 4.5). The objects having a consistent geometrical topology can be analyzed under the inquiry of 4D printing that changes shape according to the applied forces[111]. It is significant to regard the novel possibilities of Industry 4.0 regarding the potentials of Objectile for self-sufficient actuator systems and sensorial infrastructures for sensing the skins and environments of those artificial ecologies. According to those dynamics and conceptions, these technological capabilities evolve from fibrous composites to nanotechnological crafts in consideration of material qualities.

With previously identified research on the latest theoretical endeavors upon the laws of thermodynamics and evolution, similar inquiries on human-technology-environment interactions can again be scrutinized via their quantum-related resolutions. The biological as well as ecological dynamics, for example, can be assayed and associated via quantized planes of references among physical, biological, and chemical reactions and dynamic relations. The activation pattern of plants'

[111] The things emerged in the thermodynamic equilibrium are adaptable to the conditions of external systems.

photosynthesis (Bejan, 2016) can be measured, for example, by their usage of water and its transformation into oxygen or CO_2 and into sugar and energy that can even be assessed via quantum entanglement of the same photosynthetic reaction of different activated cells of leaves (Wikipedia, 2019, Quantum Entanglement). On the other hand, graphene-based wearable nanoscale materials can also be designed so as to facilitate electron flow. Activation of similar electron information yet again would be the similar sunray pattern, and those membranes can carry or recognize the fact of entanglement at certain zones of formal emergences. Similarly, such artificial membranes as attractors within the environment (Figure 4.5) in different scales can even be a systematic solution in the upcoming years (Landhuis, 2020).

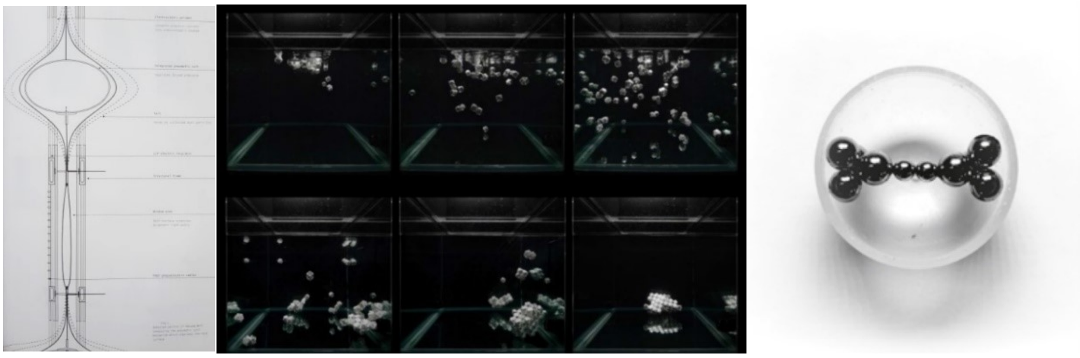


Figure 4.5. Vacuum wall (Kallipoliti & Tsamis, 2013), (Left); 4D printing from self-assembly to evolutionary structures Fluid Lattices, 2014 (Middle), Self-Replicating Spheres, 2015 (Right) by (Papadopoulou, Laucks, S. Tibbits, 2017)

The new scientific inquiries also lead to novelties of natural computation. Regarding the biological processes in our bodies, Pallasmaa takes into consideration of discrete Living behavior that can generate a new understanding in this revolutionary age regarding the architectural education and the research domain of biology (Pallasmaa, 2019). This idea has a place in the scientific investigation of how information processes can be shifted towards the biological and physical bodily activities and the existence of discrete creatures in the creative evolution of life. It is because bacteria do also inherit entangled biophysical particles (Quantum entanglement, 2019; Chu, 2019). This feature can enable monitoring the existence and informational activity of entanglement in biophysical and bodily activities, and explain why our imagination and understanding should not be related only to classical informational activities. On the other hand, it is appropriate to argue that our DNA structures have cellular information that already generates our biological codes and features (Chu, 2019; Landhuis, 2020).

As a return to the physical description of entanglement (Appendix D), *the cyber-Garden* project can be considered as a creative example. It has the potential to use bacteria's ability of photosynthetic production and the entanglement of sunrays in the bodies of bacteria (Quantum entanglement, 2019). Puckett reports a similar project by Marco Poletto and Claudia Pasquero (2011) (Puckett, 2013), which has an analogous approach as in the project of Contaminant (Pike, 2008b) (Figure 4.6). From the second law of thermodynamics and the entropy-based informational flow, it is significant to follow how the registers of artificial agents and nature process those environmental inputs and restore them as a natural form of cellular memory in the association of different organic/cellular/informational materiality and patterns of their energies.

Figure 4.6. Homeostatic membrane integrating the electronics with nanotechnology and thermodynamics (Left); "Nonlinear Systems Biology and Design' workshop cluster at SG 2010, IAAC, Barcelona, Spain" (Sabin, 2013) (Middle); Contaminant by Pike, 2008 (Right)

Investigation on informational form and matter in duration can be searched in the cases of shape memory alloys and shape memory polymers (Vazquez, Randall, Duarte, 2019) that can be investigated by quantum fields and nanoscience, and the 'registered' territorializations by thermodynamics. Those inquiries can generate new interfaces to be investigated among human-natural and artificial agents besides being performative materiality for architecture. Thus, the common basis of cellular memories stimulates creative or rational thought, and can also be a part of the adaptation, generation, or growth process. This statement also indicates where Natural Computing should strategically stand in the paradigm of 'environmental topologies'.

To mimic biological systems, artificial systems can contain the related information as entropy for actual patterns of the characterized form of things (Nakahara & Tanaka, 2013). The common interfaces between the artificial and natural systems cannot be regarded as being outside rational constraints. The superposition or corresponding correlation between different systematic references defines a domain of adaptation to each other. Environmental adaptation of virtual and actual aspects with qualities of information, agencies, and systems has a significant place in the evolutionary conception of duration (Bergson, 1998). Adaptation indicates an evolutionary change for the distinctive or discrete entities; and establishes the common sense or principles that are reserved for the persistence of life as an open system (Bergson, 1998). This change can be applied as a study on how architecture has generated the ties of creativity with technology.

What makes the current inquiry much more interesting is the rising curiosity upon the human-computer interaction and its productive interfaces on its actual and virtual grounds. Emotion and consciousness are significant to understanding the impact of affect in designing humanized interfaces of artificial creativity, and lead to the adaption of the subject-agent as the designer or the user of those interfaces by pushing the subject into a training period by getting accustomed to the new logic of artificial rationality. The condition of subjectivity that is scrutinized under the effect of sensual, emotional experiences in certain time periods and the state of consciousness accordingly implies a long-standing durational process of evolutionary creativity.

In this study, the joint actions and potentials of creativity on the common grounds of those energetic fields of duration are further analyzed with regard to the correlation between the artificial, natural, and human agents in the sensible territories (Guattari, 2013), and their virtual knowledge, as information-scapes. One significant example of environmental coexistence of artificial and natural systems is found in '*Nonlinear Systems Biology and Design*', networked through intricate manifolds at the connection of relations of artificial and natural systems that are arrayed in matrices (Figure 4.6):

> "we focused our efforts upon simulation of nonlinear behaviour in cell biological systems and the translation of this behaviour into material systems and fabrication techniques, namely through 3D printing." (Sabin, 2013)

The systematizations of geometrical, material, organizational, and discursive processes, elements, concepts, and representations (or any other generative concept, such as *phylogenesis*) correspond to the efficient usage of digital tools and scientific explanations of the digital pool of an ecosystem as a memory of form and material stabilities. Accordingly, the genetic pool tree as a tool integrating genetic and evolutionary algorithms can become the generative method in the interplay between the virtual and actual by considering the role of the information and its logic. The inquiry of a common basis of the conversion of memory-based substantialization, even between Living and artificial agents, still necessitates the active usage of neural networks and the new developments in molecular computing. The emergence of the digital pool as an informational ecosystem from the aforementioned studies (on object-based identifications), then, can be discussed for the studies as a memory of form and virtuality to be converted into material stabilities towards the digital and material ecologies, data structures, and environments. Just as in the generative genetic pool tree, genetic and evolutionary algorithms in nanotechnology or quantum-based scientific inquiries still have profound intricacies and singularities to be analyzed in the future beyond their fallacies of instrumentalization.

It is also desirable to envision the architectural environments designed for the scientific and new technological inspections as testbeds (Howie, 2019; Erler, 2019) to develop natural and molecular computing. The example of tiling the facades of the buildings by forms of vessels with biopixels with the ability of photosynthetic production apparently reveals the change in height, air, and light conditions (photo.Synt.Etica, Dublin, 2018) (Pasquero & Polletto, 2019; McElroy & Rosenow, 2019). Moreover, the difference between the inside and outside conditions of the built environment can be parametrized as an energy-efficiency problem in similar approaches (Bui, Nguyen, Ghazlan, Ngo, & Ngo, 2020). *ecoLogicStudio* has made a series of experimental exhibitions in a similar search, in *photo.Synt.Etica* (2018), and in *HORTUS XL Astaxanthin.g* (2019) discretely (Figure 4.7) (Pasquero & Polletto, 2019). The coherent integration of the built environments with artificial-natural agents can be increased with technological transformations regarding biopixels as environmental and informational (entangled) bases. In the evolutionary transformation of computational design thinking, it is significant to regard the interface between human-computer-environment interactions regarding the negentropy and energy-based complexities (Song, 2013), and the evolutionary role of the built environment that coexists with the transformation of technology. It reminds one of the role of the built environment in the monotonous evolution of the human-environment interactions over a long time, which defines the durational pattern of the built environment in relation to subjectivity, culture, and changing technology.

Figure 4.7. Bio.Tech Hut Pavilion, Astana (2017) (left above and below); photo.Synt.Etica, Dublin (2018) (middle); HORTUS XL Astaxanthin.g, Paris (2019) (right) by eco.LogicStudio (Pasquero & Polletto, 2019)

4.1.4. Excursions on Modalities for the New Logic of Human-Computer Interactions

The 'subject factor' in the topologies of human-computer-environment interactions can be grasped via Bergson's (1920; 1946) and Felix Guattari's (2013) analyses of the corresponding relations between matter and mind through the laws of thermodynamics and the related flow of things, energies, and entropies. As a return to the necessary basis of research for 'humanized technology', relational concepts and their discursive relations regard the interfaces for subjective experience to be among the definitions of Subjectile and Objectile. The flow and language are built up with reference to Objectile in the abstract and concrete machine mechanisms (Guattari, 2013), and are to be analyzed by the profound inquiries about memory, attention, and territories in which Objectile emerges and resides. Reading territorialization (and deterritorialization) with the theme of Objectile, human interactions, and interfaces require the phenomenology of substantialization (Guattari, 2013). The revolutionary logic between Subjectile and Objectile with regard to the further advancements in nanoscience and quantum technologies by the logic of growth, emergence, and persistence of evolution of agents of artificial-natural togetherness of abstract and concrete machines, then, can be further based on:

- *Thermodynamic rules and their relation with the evolution*
- *Evolutionary emergence*
- *Their relation with informatics and entropy-related energies (regarding negentropy) and quantum-based principles/applications*
- *Geometric/Topological substantialization and morphogenesis of things*

Some of the interfaces and design methods in architecture are not alien to these interdisciplinary discussions in the development of human-computer interactions. The study explores the immediate contact between the real practice and imaginary thought; and Objectile-Subjectile relations with territorialization and deterritorialization of spatiotemporal practices, analyzing Guattari's four concepts (Guattari, 2013):

"5 Diagrams": Diagrammatic tensors have external projections of internal recognition of one individual regarding territorial and spatial configurations that are generally abstracted as geometric formations. As can be followed in the profession of architecture as an interest, diagrams are commonly used in design thinking, in the abstraction of ideas into forms, and the conceptualization of realities into constructed thoughts as 'projects'. For example, Peter Eisenman's diagrams evaluate the elements of thought by conceptualizing perception and senses, and sophisticated thought, into form-like structural and signified notations and matrices. Those can be enumerated as the signifiers and identifiers of design in the modes of consciousness and emotion (or drive-based insights) (Eisenman, 1999; 2005; Eisenman & Galofaro, 1999).

Mitchell, on the other hand, does not directly exploit the term diagrams. However, he utilizes the abstract approach of defining each entity as a part of diagrammatic thinking for architectural technology of logical identification for each external parameter of predilection and feature-based properties of internal formalisms. Mitchell uses diagrammatic thinking by exploring the parts and whole of buildings in the computational logic for architecture by conceptualizing the language pattern and grammar of elements, features, and properties (Mitchell, 1994). The importance of diagrammatic thinking is to augment the intersection of artificial-natural togetherness. It enables one to be freed of the blind-logic of computerized information that does not intuit the external forces and formal aspects (Tüntaş, 2018).

Moreover, training the 'blind' logic of computers under the lights of diagrammatic thinking can be innovative for the development of humanized technology if the togetherness of the 'four' primary tensors is thought together at once for the practical realization of such imaginations. It is prominent for architecture and the drafting tools of engineering and design to be developed with the logic of artificial intelligence and cognitive science. Executing creative diagram sets with the help of genetic and evolutionary algorithms in clustering, selection, and crossover of corresponding diagrammatic entities and features that are conceptualized and represented can imply one way of generating common interfaces for human-computer logic. As an inquiry of problematizing the imaginary togetherness of thought of expression and content into iterative forms of codes and declarations, the corresponding statements and arguments for the common logic between humans and the artificial can be founded further in the exploration of machinic propositions.

"6 Machinic propositions": According to Guattari, machinic propositions are derived from humankind's abstract logic, which can be represented as the abstract codes, expressions, statements, and arguments that internally determine the computer language and logical structures (Guattari, 2013). This project focuses on developing artificial intelligence of these technological media such that they can recognize, identify, and make further reasoning and suggestions about the fundamental axiomatic and deductive relations of geometries and properties. The tools can be transformed into the agencies of logic and design, and can predict reliable and humanized assumptions from fuzzy sets about the formal emergence of things (or Objectiles) and the built environment beyond those axioms as generating self-reproducing statements that are intelligible to logical reasoning. Although it seems solely primitive in its logic, Mitchell steps the initial phases of similar reasoning. He first identifies the coordinate system of lines represented by the start and endpoints as static linear systems besides the operational commands (Mitchell, 1994). However, such a system constitutes most of the mastered production techniques and still has been used in the similar constructive logic of computation, design, and production of Industry 4.0 in architecture and in the background of most of the associated software.

Learning and generating the intuitive declarations and higher dimensional matrices of topological geometries can also enable the interpretation of non-linearities of non-Euclidean, non-Cartesian geometries. These are dependent on the inference from certain rules of ontological emergence of form and geometries, which are the axioms and deductions that should be expressed clearly. On the other hand, neuromorphic chips' futuristic potentials can be considered to be used to recognize intuitive geometrical bases and shapes. It would then be possible to train artificial agencies by complex geometries departing from 3D point cloud methods (Gürsel Dino et al., 2020) that even humans cannot simply recognize at once. By such an ideational inquiry, artificial agents can make interpretations and even intuitive descriptions and assumptions as a discursive intelligence in the rise of neuromorphic computing chips and new script-based solutions (Appendix C). However, those can only be asserted first by introducing the logic to new technologies via the axioms of correspondence, congruence, and the evolutionary logic behind the infinitesimal rotations, the absolute planes, geometries, and ideal points in the definition of descriptive geometries. That makes recognizing the complex geometries that are to be drawn, recognized, and identified by these technological advancements not as media but as the agent of design, possible. It can be the step towards the expansion of the field of knowledge of architecture, which is the ultimate aim to be discussed in the autonomy of architecture, implicitly and explicitly regarding the externalities of technology (Appendix C).

Previously, in the construction of geometrical axioms and further iterations of non-Euclidean geometry, the attempt was made to describe the fact that intuitive capacities are significant to envisioning the future of computation with reference to geometry. With regard to this statement, the sensed objects can be expected to be identified and predicted with their classical elements of points, lines, and surfaces, as well as by topological inferences to be distinguished from environmental noise by the discursive capacities of artificial intelligence. Nevertheless, the current technologies of software for design and drafting, such as Rhinoceros with the Grasshopper add-on (Payne & Issa, 2009), can only identify the surfaces in relation to their changeable variables that construct the surface without reference to descriptive geometry. 'Surface Morph', for example, can be used to decompose surfaces if, and only if, there exist some predetermined changing variables; yet again to be used to construct the same surfaces with the constrained parameters and their changing values of Grasshopper by itself (Sorguç, Özgenel, Kruşa, 2018). On the other hand, to decompose the parametrized inputs that are predicate on an object is much more complicated and necessitates at least 5-6 or more steps to construct surface morph command itself and does not assign the decomposed elements as free entities but only recognizes them as changeable variables.

In the development of new and alternative technologies, user-friendly interfaces are strongly recommended for the practical operations on a perceived object; without constructing them from scratch or even constructing the dissolving parameters for a defined working command or algorithm. The problem does not even arise from the logical complexity of the morph code itself but the 'blind syntactical logic of classical computing' and its scripts. There cannot be any intuitive capacity of classical computers other than their data structures (as pooling the processed information) to perceive and recognize sensual objects. They do not even have a solid Cartesian logic or Euclidean axioms to construct those geometrical modalities. Yet, there are two ways; the first approach is more rational, namely by making computers learn the axiomatic iterations of geometric combinations to construct objects.

Similarly, learning shapes and properties of materials/elements/geometries (Yazıcı & Tanacan, 2017) (like the code of/for RGB colors) as in the studies of perceptron neural networks (Pan, Sun, Turrin, Louter, & Sarıyıldız, 2020) can be similarly developed. Beyond this provision, it may be possible, for instance, to follow how neuromorphic computers by attention mechanisms can distinguish singular objects with consistent properties in different views or moments only by filtering out the environmental noise and other inputs (Appendix C). Introducing the non-linear geometry and the ability of humanized technologies to neuromorphic chips to make guesses, intuitive inferences, and discursive predictions, hence have great potentials.

"7 Sensible territories" (Environmental interactions in the togetherness of Objectile and Subjectile): Sensible territories describe the transference of sensorial spatiotemporalities into the perception and imagination of subjectivity. This necessitates considering the recognition of objects in the convolution and training problem of the images and external forces, actual and virtual capacities of creativity of subject, and artificial agency in design and production. It corresponds to the long-term durational projections for the integration of agent-based design approaches with spatiotemporal experiences, including the clauses:

1. Artificial or natural agencies can be part of the long-term evaluation in relation to psychophysics and the emergence of feature-based recognition
2. Spatiotemporalities and architecture can be debated on the contradiction between the rational and organic; orthogonal and topological

It is compulsory to claim here that the classical means of computation could not make further progress about guessing the emergence of shapes and their further 'topologies' without the help of sensorial data. In that regard, the development of new hardware resources carries paramount importance in integrating sensorial data directly to computational design-thinking by converting the sensorial mechanisms into the logic of computation in a learning epoch as an intuitive approach. Respectively, it is helpful to introduce how classical neural networks distinguish the consistent repetition of the object in a noisy environment that is distinguished with its coherent property-based relation. In the conversion of the real into imaginary, and actual into virtual, convolutional neural networks take over the task of generating the common interfaces between what the human senses and what informational bases register. As we attempted to introduce previously in the possible grounds of intuitive sensing objects and Objectile, it is here to conceptualize how artificial agencies can work out the sensorial tasks in the sensible territories that sensorial mechanisms of humanity can achieve. For instance, Convolutional Neural Networks (CNN) can be abstractly modeled to recognize the morphogenetic and property-based data (as even generating identities by special functions) of objects. So, the means of assessment of the accumulation of emergence of things in duration can be represented as the accumulation of coherent information about the object (Figure 4.8) that would be coherent in different states and time-based frames, as the identity of objects. Accordingly, their complexities can be assessed only by some convolutional methods. Figure 4.8 and Table 4.1 show how the neural networks are trained by random examples/image/objects/Objectile having the abstract depiction of accumulation of inputs/data and the task of convolution with reference to one selected feature/entity/object. The training session represents one of the genuine examples of how classical CNN (Table 4.1), using a classical Intel Core i5 chip, can recognize visual objects by having 100% success in validation accuracy over 222 examples having the learning rate of 1e-5 (0.00005) to subsume back the potentials of Loihi, neuromorphic computing chips.

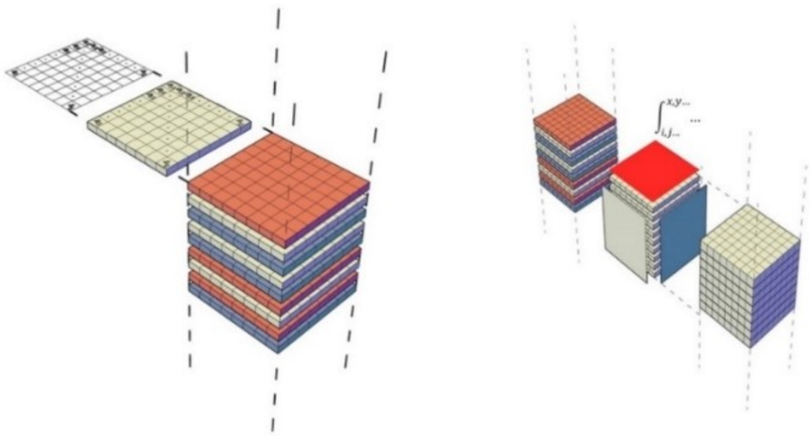
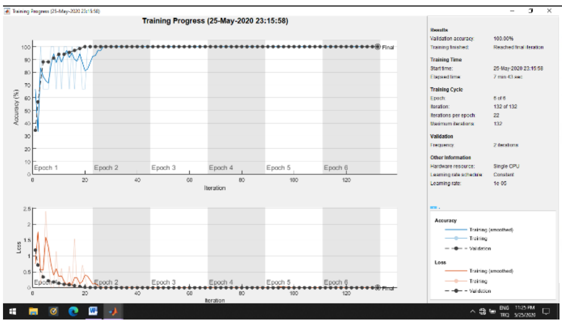
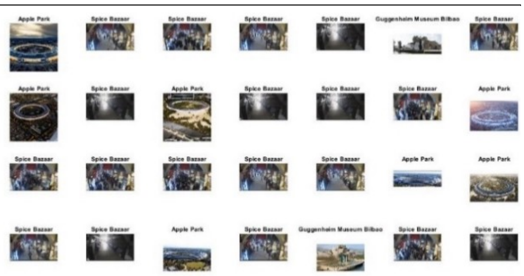


Figure 4.8. Abstraction of a systematic approach in the convolutional neural networks in the accumulation of data as the properties of things (emergences) (Drawn by the author)

Table 4.1. Experiment on MATLAB CNN Alexnet

	
1. Training Progress with six epochs and the outcomes (by the author)	2. Random Prediction on the Trained Data (The buildings are Guggenheim Museum in Bilbao, Apple Park in Cupertino 2, and the Spice Bazaar in İstanbul)

“8 noema”: Noema corresponds to the intelligible concepts revealing the role of language and form of subjectivity and intellectuality (Guattari, 2013). Accordingly, it is possible to distinguish the role of subjectivity (and its distortion), the linguistic constructs, and discursive interpretations from other domains by discursive analyses, for instance, at the intersection of tensors (Guattari, 2013). It is also possible to argue how creativity can emerge via noumenal executions. On the one hand, it is possible to define creativity’s rational description to make the unmade by subjective preferences, whilst on the other the intelligible action of abstract language can be defined as constructs among the corresponding elements, objects, and things. According to this, it needs to again reconsider the overly rationalized approach of the project of axiomatic expressions (Appendix C). Kurt Gödel’s critique on the impossibility of some propositions of axiomatic description that is noted by Philippe Morel (Morel, 2019) can be accepted as a critique for three-dimensional Euclidean space. Regarding the non-determined declarations on certain entities and beings, the suggestion is to think over the generation of discursive and intellectual expression on the nature of things creating a virtually correlated pattern. It also reminds one of the difficulties of the challenging project for a universal machine that may generate creative and intelligible discursive patterns of linguistic constructions beyond human-imposed parameters.

From the axiomatic construction of things to creative declarations of the subject and the envisioning of discursive machines that construct human-like intelligent languages and structures, the construction of intelligible objects via linguistic practice makes us understand the role of subjectivity to be re-evaluated by information technologies and the logic of architecture. It is here to propose the ‘topological’ role of subjectivity and its cognitive processes that generate creative design and production. This inquiry can also enable us to grasp how the machinic propositions and noumenal executions can encounter and make a creative endeavor in the architectural profession. It reveals the significance of existential territories’ sensual experience to catch the difference between the data and information and distinguish the role of noema from the common basis of existential territories or other territories by the common basis between humans and artificial agents. Accordingly, the formal logic of architecture depends on the relationship between the form of external information and the qualities with absolute or utopian autonomy. Possibly, autonomy lies outside the ultimate correlation between the conjecture and architecture, which is virtual to the present and possibly actual in the future that may never come, and remains the potential topic of future study.

Moreover, the integration of the fuzzy system of subjective inputs and their correlating feature-based algorithms in recognition of objects as a convolution and training problem of images, for instance, can also be discussed as the potentials to train the emergent neuro-fuzzy systems. As including most of the property relations (such as color and shape) in the object recognition, and even for the prediction and projection for the design of self-reproduction, these considerations also broaden the way for realistic self-manufacturing to be again based on nanotechnological feature-based algorithms. It also brings forth the life of architecture and its elements as design after design. By envisioning the assembly of self-sufficient materials, the degree of attrition on the tectonic materials (Özgenel et al., 2018) can be virtually controlled towards a new mode of production and sustenance of behavior of materials and assemblies. Architectural intelligence, then, can generate radical feedback from the particular circumstances of its environment as pragmatically and theoretically coherent intelligible data structures and even noumenal concepts.

Accordingly, the connection of 'noumenal values', 'the diagrammatic thinking', and the tensor product of 'the flow of things' should be intersected via the 'territorial empiricism of the environment' as an open system that augments the level of sensual judgment through the sensorial system of closed artificial declarations. Then, it is also possible to propose some creative methods to determine generative models between diagrams and machinic propositions with regard to the informational grounds of genetic algorithms to be trained with sensorial data further. It would also represent a new attempt to evaluate the diagrams as generative design tools and new means of computation to be based on a creative taxonomy of 'properties' and 'emergence' of things to be defined by informational grounds of genetic algorithms.

4.1.5. Concluding Remarks on Duration in Evolutionary Profession of Architecture

From the works mentioned, there can be found rules of evaluation of perceptual and imaginary projections of subjectivity that are directly engaged with the spatiotemporal actions, energies, and object representations as an endeavor for architectural growth of described potentials of the 'project' (Aureli, 2013a). The interfaces of new technologies can enable flexible common grounds of interaction, communality, and participation regarding the new roles of Subjectile. The new logic of computation offers modern authorship for architect-scripters not bounded with social bonds and community but has an alliance among technology, complexity, indeterminacy, and mysterious capacity to self-organize natural and social systems (Carpo, 2013a). The virtual condition of current technology can be stochastically linearized as subsequent agents, networks, and texts, images (or other types of manifolds of sensuality) of design activity, even if it is somewhat at a distance from the actual product of Objectile.

Aureli seminally introduces his concept, 'project' as the way of the imaginary procedures of design-thinking, starting to analyze professionalization of architecture from the initial formalizations (like Alberti's perspective) and dichotomies (like Brunelleschi for being the architectural master) in the Renaissance period (Aureli, 2013a; 2013b). Regarding the togetherness of the Living and artificial by the respective role of the imagination, it is extremely significant to envision the constructing relations using the generative new mindsets of performance, Affect, and intelligence. As the transactions and other phenomena are associated with the cortical regions of imagination and memory for creative integration, such procedures require a consideration of the imagination and memory as well as the attention mechanism regarding duration as a mind-intelligence-cognitive concept. The critical question of the substantialization of topological interactions among humans, nature, and technology corresponds to the form-matter-substance conversion of knowledge that is restored as memories in the evolutionary conditions (Guattari, 2013). The memories of a subject, the built environment, and the organizational/collective mode of practice and theory in the generation of the conscious mode of decision-making correspond to the durational field of knowledge in the monotonous evolution of trajectories of architecture.

Bergsonian analysis of memory and mind further creates a plane for consciousness in question with matter-form and memory of subjectivity (and of universality) by the interpretation of axes of space and time (Bergson, 1927; Deleuze, 1991a). Bergson explains the successive stages of the connected visual perception and cognition processes within the substantialization of perception, virtual to the pure memory as a stored experience, communicating with the pure faculties transferred through the set of memory-images as kernels of appearances. In this respect, memory images are the agents of vision that transmit as well as reflect the perception into pure memory.

The intersection of Objectile and Subjectile can also be intersected at the explored tensors that Guattari introduces. From the interfaces of design to the screens of virtual and augmented reality, the togetherness of subject and technology in recognition of space provides the evolutionary development of form-matter-substance conversion with and beyond informational grounds. It even becomes possible then to identify some of the systematic and bodily interactions and identity-based as well as cultural considerations. To better understand the complexities of subjectivity by memory, matter, adaptation, evolution, growth, and transformation in time as durations, the modalities of memory and its informational correspondence in accordance with its divisibility or its intricate stereotomy should also be questioned. This inquiry should be run through the (cultural and natural) identities of things with divisible or non-divisible energies as durations in environmental interactions. The complex investigation about the cellular memories of natural or even environmental computing, thus, will necessarily look for further complexities of natural and cultural identities besides their fully determined energy-related physical force fields.

The 'identity' as the order of things in duration coherently repeats its property-based relations or cultural traces (almost like tradition and craftsmanship) in technology, culture, and civilizations. It is to search, then, how the architects should construct their identities as well as their culture and built environment. It is also possible to define the evolutionary construction of memories and identities by production relations that take shape again by the industrial and informational revolutions throughout the decades by the built environment we live in. From the emergence of Grid as a planning tool to Hausmann's creative destruction, and to the recent technologies by the industrial revolutions, the evolutionary transformation of the built environment, as in the cases of campuses, can also be understood by the technological, industrial, and so organizational changes by consistent environmental identities and durations. The intricate geometry of Gaudi's Sagrada Familia Basilica, as another peculiar example to this, still pushes the limits of technological advancements just to catch the original characteristics of Gaudi's design due to the intuitive depth of its projective geometry that is mastered at the end of nineteenth century by these periods' architects. (Burry, 2011a; 2011b; 2013). By exclusively giving the example of Basilica, Burry tells of his experiments since 1979, connecting the past with the performative endeavor of the present in this duration with the influence of Gaudi's contribution in mathematics and design (Burry, 2011a; 2011b). Accordingly, Mark Burry narrates his journey of exploring Descriptive Geometry's principles in Computing Geometry (Burry, 2011; 2013; 2014) through experience with digital software to solve the mystery of the geometrical design and construction of Gaudi. Accordingly, it is possible to read the evolutionary transformation of architecture in practice by grasping geometry's role in 'the evolutionary memories of the built environment'.

Organic forms such as Gaudi's Sagrada Familia Basilica with hyperboloid geometric surfaces (Peters, & Peters, 2013) can best be engaged with the twenty-first century's information technology in Mark Burry's work for completing this masterpiece. As he points out, nevertheless, the nineteenth-century architects' mastery over the descriptive geometry by being a part of the education of the architects (Burry, 2011a, pp. 102-119) has not been disclosed by the advance of informational technologies and means of coding algorithms. Thus, it is the evolutionary construction process of Sagrada Familia Basilica that integrates the professional inquiry of the past with the current capacities of information organized for the completion of the project. The duration of this masterpiece reveals the creative potential of the artificial, which requires education on the geometrical intricacy of the nineteenth century. The evolutionary progress of the profession of architecture can be followed by how the material qualities and the earlier decades' design can be revitalized through new materials, design, and manufacturing techniques. The creative progress of co-evolutionary trajectories of design and technology reveals the mysterious power of designing that is scarce but apparent in particular cases, like Sagrada Familia Basilica.

When regarding the evolutionary transformation of the profession with regard to its internal dynamics, ‘organizational memory’ (as a cultural pool) should also be taken into consideration in an evolutionary trajectory towards the critical understandings. To batch the processes in discrete and simultaneous platforms and organizations of design as well as manufacturing further, the coexistence of multiple platforms of open-source collaboration tools (Kilian, 2013) seems the ultimate way of entangling the information for the performative efficiency in creative evolution and architectural intelligence as ‘the after-life of design’.

However, the potentials and premises do not hinder the ideological and critical interpretations of the last decades’ fashionable mode of designing even though the complete design agenda would correspond to a much more sophisticated development schema in science, technology, and logical reasoning at different scales of thought and production. Connected and networked global working environments worldwide, for instance, signify the global procedures of architectural intelligence and its practice. Parallel to this, class struggles increase asymptotically, including social rights and the security conditions of immigrant labor, their lack of environmental comfort, and the segregation and even racism and ethnicism (Wilson, Carver & Baxi, 2015). Online collaboration cannot be seen as sufficient means to overcome collective action challenges in that regard. The role of the university and education to produce knowledge (Hoorn, 2014; Aureli, 2015), on the other hand, is as critical as a factory to produce goods (Metahaven, 2015; Klein, 2015).

At that point, it becomes crucial to remind of the culturally and socially critical condition of neo-capital politics holding the efficient means of technology that also become the dominant legitimization tools of architectural performativity and its organizational capacities. In this regard, it is crucial to remind of the concepts of territorialization and deterritorialization once again when reading those concepts together with the new dynamics of production, its technology, and subjectivity that the meanings of Objectile and Subjectile ought to gain substantial meanings, *per se*. Nevertheless, these modalities can only be fully grasped once the separate/discrete concepts and active discussion on the narratives on motion can be surveyed entirely with some exceptional singularities/intricacies in durations having string-like territorializations.

The other concerns associated with architecture related to this inquiry may still lead to some accidental architectural unexpectations beyond formal domains like a building's shape as a message in the set of architectural 'signs' as a symbol or 'image' and computation for internal organization and generative structure of the architectural object. The latest manners towards the bio-inspired scripting, for example, may lead to identities even just like International Styles without any reference to local dynamics as also replacing the architectural autonomy in the creation of 'architectural' objects. This mannerism also threatens the architect for being the digital technician that can retotalize everything with its predetermined and mass customized geometric and manufacturing aspects. Nevertheless, the potentials of artificial creativity are still on the agenda of change within the general domain of computational (artificial) mode of design with new noumenal attributions regarding the entanglement of design with art, technology, and the new media. It is to see the recent endeavor of the architectural profession beyond the stylized or famous eulogies.

What makes the future unique again is the experience itself, the collective expectation on the events that generate the phenomenal randomness of life as in NP-hard problem. Computing everything may have nothing to do with the problems of "being and living together" that architectural systems must solve. It should be used to catch the accidents that happen repetitively as predetermined forms and patterns of behavior. This computational process is also related to the 'properties' of things as the architectural objects' emergent identities and their registered memories. These properties should correlate special filters with the architectural endeavor itself rather than engineering or sculpturing formal aspects. The critical aesthetic tactics in complex relational systems for new perceptive and affective mechanisms between subject/object and subject/subject in the space should be improved under original relations. Yet, computational architectural strategies can offer new dynamic properties for the environment, but they should not be arbitrary in the sense of formal aspects without utilitarian, political, or cultural aspects.

However, such intricacies can only be understood by being in the know of advanced inquiries of complex space-time concepts. Such singularities can correspond to the complex collective dynamics in the togetherness of territorializations and deterritorializations first, or otherwise rest in the confluential complexities and fluctuations of non-linearities of forces, organizations, and challenges.

Thus, the sub-chapters of Modulations and Modalities can be seen as generative research bases that also make us able to reread those previous complexities of the third chapter. Methodologically, however, rather than only reclassifying or making direct segmentation for each discussion in the repository of the third chapter in analysis, the modulation and modalities also generate discourse for the necessary means of clustering. In short, the study attempts to generate research bases to dissolve and constellate the discovered complex relations in the third chapter into the corresponding modulations, and regard science and technology-based modalities concerning the futuristic possibilities of human-technology-environment interactions/topologies. Respectively, the study continues with other concepts of derived space-time theories that not only make us critically understand the precedent conditions that can be clustered easily under each different sub-chapter but create generative means and methods to presage novel modalities with many different examples/conditions. Such research is also believed to be of help in finding out the singularities that should be scrutinized further and even produce novel paradigmatic bases/agendas.

4.2. Motion and Action in the Fluxes of Becoming

4.2.1. Introduction

Investigating the related research domains for increasing human-computer interactions and new production relations of Objectile, this subchapter includes examples ranging from smart objects to smart spaces analyzed through interactive, responsive, and adaptive learning intelligent environments. This research also attempts to find the gap between the different scales of sites for high technology that cannot yet be fully reflected in the culture of the built environment. At the architectural and societal scale, similar principles vary among different parties of production and design. Urban informatics, on the other hand, is another way of hybridizing movement that distinguishes the chaotic complexity of various paradigms at a larger scale. The analytical studies on the existing city spaces and new ways of organization and crowdsourcing of agents and environments, as a product of precedent industrial revolutions, show the modalities of the flow of things that are subjected to new technologies.

The non-linearities of topological geometries regarding the intricacies of 'strings' that Lynn explores (Lynn, 1999; Jones, Robbins, 2010; Blumenhagen, Lüst & Theisen, 2013) also reveal the challenging combinatory complexity of nature for computation as in natural computing and supercomputers. It is significant to distinguish Lynn's suggestion of a form of human-technology interaction criticizing Frazer for the instrumentalization of nature for computation. Relatively, the human-robot interaction goes beyond the idea of theoretical endeavor that makes use of the Augmented Reality like Microsoft's ComputerVision API (Niquille, 2019); and becomes even the ideological reality of the 'spaces in flowing relations and motion'. The rising robotics studies maintain seminal research, as in the case of Boston Robotics' *SpotMini* project that DARPA financialized (Figure 4.9). Respectively, the recent studies in the automation, robotics in construction, and design-related perceptual processes by human-robot interactions (Figure 4.9) (Kyjanek et al., 2019) reveal the necessity to understand the reciprocal relations of the human-nature-technology relationship as a topology with regard to the physical forces and dynamics in the environment.

Figure 4.9. SpotMini (left) (Niquille, 2019), ICD-ITKE Human-Computer Collaboration (right) (Kyjanek, et.al, 2019)

Lynn's inquiry on topological geometries and curvilinearity has also disseminated a mode of freedom for designing in the information age with the rise of CAD/CAM technologies. These developments also refer to the efficient non-standard production regarding the applied forces within the interacting environment towards the formation of the creative evolution of modalities in the multiplicity of different agencies. Accordingly, Objectile corresponds to the technological object having the three-dimensionality of being a product of non-standard manufacturing (Cache, 1995) that can be creatively generated by the inquiry of the shared informational grounds. At that ground, human-robot interaction occupies significant places in the ecologies of design and learning environments that can enhance the creative possibilities and informational bases in action by topological parameters and applying forces through the concepts of Subjectile and architectural technology.

Methodologically, the production relations and complexities in geometrical references of Objectile together with those topologies of human-technology-environment interactions' agendas can be exemplified and grouped by modalities and modulations via spatiotemporal territorialization and deterritorialization. This method is also based upon cognitive and behavioral research that founds the challenging notions of collective, organizational, institutional, and productive capacities in the emergence of intelligence, which, in the end, defines the architects' collectives. Regarding the coeval change of technological growth in the spatialized tradition of industrialization, the rise of high-technology sites, for instance, must be examined in the changing dynamics of creative evolution in architecture. Accordingly, the larger-scale relations of the flow of things belong to the informational revolution, and territorialize at specific points, such as Silicon Valley. In the recent period of design of technology campuses of giant commercial headquarters, Apple Park or Googleplex can be described as the recent examples of built environments. By recruiting the professional organization of design firms such as Foster + Partners or BIG Architects in long-term projects, the dominant market relations of technology with the higher sway on the design decisions reveal the dynamics of spatialization practices at such scale. The motion, however, is more than the materialization of architectural practice. Castells describes the constant flow of information (Castells, 1996; 2001); Mitchell (1995; 2003a; 2003b), Virilio (1986; 2005), Augé (1995), and Vidler (2000) also analyze the external forces of globalism in transforming the subject by understanding his/her presence overall.

Thus, both the theory and practice of architecture are vibrant and resonating processes, considering design as an evolutionary form of intelligence. It is part of this intelligence that architectural practice is heavily affected by the paradigm shifts in science; thus, the advancement of technology is closely related to the collective embodiment of professionalization. This intelligence calls for a process through which the architect as the networked individual is now subjected to formal procedures. Through globalization and the information age, the concept of motion is an essential and yet challenging issue for the agency of this intelligence, namely the architect at all levels, cognitive, societal, organizational, and the modes of production.

Accordingly, the multiplicity of new collective agents of technology (and design) in the information age requires the redefinition of the roles of each agent and their performative endeavor as an urban perception to be surveyed through the analysis of the concepts of motion-effected realities. What makes the social intelligence of the spaces of motion consequential is the transfer of information between the relevant agencies and multiplicities. By considering the problematique of multi-agency in design activity, the chapter proposes alternative social, theoretical, and technological interaction models in the perception and design of the architectural environments by various scenarios of technology transfer among different institutions, agencies, and design cultures. This sub-chapter of the studies on the concept of motion, in short, analyzes the formations of creative agencies of architecture and the built environment at a performative, organizational, and societal scale. The architect's performance in shaping the natural and physical environment is explored through the design process and the concept of technology transfer.

4.2.2. The Rising Research on Human-Computer Interaction for Smart Environments and the Culture of Motion Spaces and its Paradoxes by Subjectile and Objectile

Common interfaces for human-artificial interactions need to profoundly discover the facilitatory mechanisms of the brain in nature to be translated or discovered as informational flows. Furthermore, spatiotemporal actions of moving agents in interactive environments in motion are believed to execute creative modalities for architectural research and technologies. In this regard, theoretical and research-based inquiries on the common bases of the nature of the brain and informational abstractions from matter and mind have excellent potential for architecture's creative evolution. It also becomes crucial to understand the principles of recognition and cognitive dynamics of individual and artificial agents in architecture to develop a shared understanding between Subjectile and Objectile of the adaptive learning environments. The common nature between subject and object can be found, for instance, in the analysis of psychophysics dealing with the sensorial attachment of the subject and its thinking and practicing actions (Lawless, 2014; Kingdom & Prins, 2016) (Appendix C). Moreover, sensory evaluation and computational neuroscience rather focus on flowing data and its acquisition (Lawless, 2014; Kingdom & Prins, 2016).

Motion in the Learning Environments: Human-artificial interactions in learning environments with the creative subject and artificial agencies express the significance of related research fields on visual recognition, aspects of other sensorial recognition and learning in motion such as maze learning, decision making, and assessments of behavior studied through psychophysics, sensory evaluations, and cognitive neurosciences (Appendix C). The artificial intelligence of neural networks (Figure 4.10) and the development of deep learning systems have further significant places in discovering the decision making in intelligent spaces with the role of artificial agents.

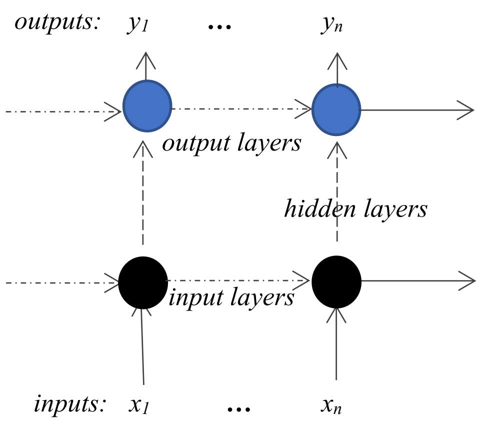


Figure 4.10. Representational depiction of LSTM network layers (drawn by the author)

Arbib's seminal article on the emergence of 'neuromorphic architecture' in the survey of *ADA Project* (2002), for instance, revealed the current potentials of neuromorphic chips creating the interspaces of matter and mind, between the subject and the artificial (Arbib, 2012). The designed sequences of spaces are based on specific learning activities, making it necessary to regard the artificial agents' logic and their evolutionary processes. Designing artificial agents by more sophisticated logical gates beyond the Boolean in the rise of neuromorphic computer chips, for instance, can do the work of the more sophisticated interaction models regarding subjectivity.

In that regard, maze learning is explored to develop motion planning in the artificial sensorial and responsive systems, robotics, cyborgs, or any other mimicking and learning agents of action for the future of architectural technologies and spaces. In the twenty-first century, the moving artificial intelligent agents can learn by supervised and reinforced input/output assessment; and can even develop some reasoning skills and efficient performance in decision making. The evolution of sensory information plays a significant role in tracking the agents' connectivity to the environmental stimuli, either visual or non-visual. The type of sensorial connectivity of the moving agent is also an issue whether it can assess the data according to the Cartesian environment or in a topological sense, besides the environmental stimulus to make fine distinctions in the agents' responsive character.

With the authentic investigations of technological research on maze learning in architectural research, it is also possible to assign design parameters of spatiotemporal actions and identifications (such as planned floors) (Maciej & Myszkowski, 2019). It can be developed as space syntax of state values for each control point or location departing from the similar logic of maze learning and artificial intelligence. This consideration also becomes common for optimizing the flow of activity pattern on the same floors, as well as the volumetric design of places by increasing the fringes of possibilities in the domain of architectural computing with the help of artificial neural networks trained by different cases (As, Pal, & Basu, 2018).

In that regard, it becomes possible to discuss the space syntax of the spatiotemporal identifications with the help of graph theory, just converting the maze learning maps into planned/designed spaces/zones of architectural/urban environments. Various mathematical algorithms regarding zone locations, dynamic states or activity patterns, or values of representation concerning their corresponding values by artificial neural networks in a conditioned environment make it possible to convert the design problem of space syntax into a traveling-salesman problem (Wichert, 2014). The sensorial reinforcement and agent-based perceptual networks in the development of learning environments and smart grids in architecture facilitate human-technology-environment interactions and predictive capacities of performative aspects of energies and behavioral identities with patterns of action. The distinction between the visual and non-visual sensory inputs in the motion plan for maze learning (Lumelsky, 2006), (Appendix C) for instance, gives the ground basis for future interactions and technological developments (Figure 4.11), and even reveals the new roles of the neuromorphic chips in design considerations and action in the learning environments.

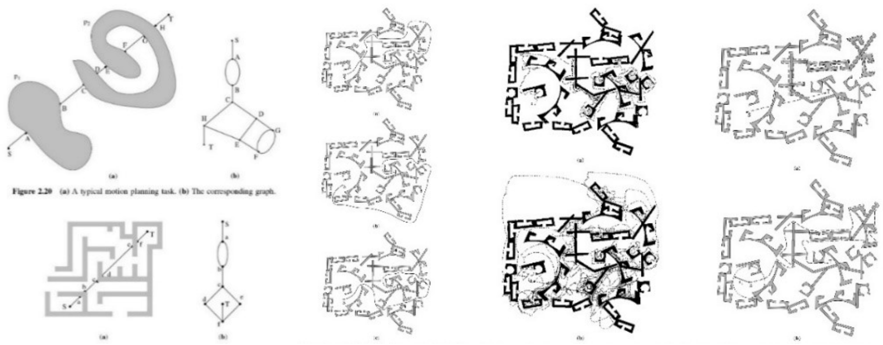


Figure 4.11. Maze of Motion Planning Task and Performance Assessment of human and robotic agents with unsupervised and supervised learning by visual or tactile senses (right) (Lumelsky, 2006)

The acquisition of knowledge from informational processes also enables us to grasp the emerging culture of 'spaces of flows' (Castells, 1996). It portrays an evolving scheme of the globalizing information age due to the shared knowledge on the networks of technology of production and consumption. The action of subjectivity can be projected in the phenomenon of society encountered with the reality of this culture. It becomes easier to understand the evolution, then, as a phylogenetical fact of mutation in the reality of social, behavioral patterns. In all, the concepts of territorialization and deterritorialization would be helpful to channelize our controversy further in the interplay of subject-object (Guattari, 2013) while dwelling on the subjectivity and its experience of knowledge (of motion). The constructed interactions among the things and identities in the nature of motion are strongly suggested to follow the same logic in its culture.

The Culture of Motion Spaces and its Paradoxes by Subjectile and Objectile: The more significant shift of science by Newtonian physics has revealed itself first in formal and aesthetic appearance with the new understanding of the Universe, events, and interactions. Large-scale machines, factories, and flowing geometry with the new morphological continuum of space inspired the First Machine Age. That progress extended to the Second Machine Age with Cedric Price and Archigram's designs, including the critical questions that architecture yet had remained fixed since Banham's ideas (Picon, 2010). The challenge for architecture was the invention of temporal buildings driven by kinetic properties of machine technology and architecture regarding environmental performance. Accordingly, some inspiring projects like Price's Fun Palace imagined the dynamic feedback between the building and its users with structure and large roof systems as well as adjustable floor plates with changing programmatic conditions. With the inspiring oeuvre from miniaturized machines of electronics, communication technology, audio/visual media till the 1990s, the Third Machine Age shows itself off in the rise of cybernetics and the advent of computing, the Internet, interaction and sensory technology, and robotics. They shared an interest in temporality as 'an ongoing cross-generational desire within architecture to incorporate time into a traditionally static discipline'.

It is also possible to evaluate the culture of spaces of motion internal to the existing discussion of production and consumption by having a closer look at the field of architecture of the twenty-first century. The spaces of consumption, for example, in the spaces of flows (Castells, 1996), make an excellent share of practice in the construction of shopping malls, airports, and many other international or large-scale projects as 'non-places' of the information age (Augé, 1995; Castells, 1996). Such spaces are the frontrunners of the capital dispersal that make the niches of the alternative capital accumulation connected to globalized companies' central growth in the information age. They are either conducted by global corporations or conducted according to the rules of neo-capitalist marketing. On the other hand, the production spaces include the described conflict of professionalization and competition as a paradigm shift internal to the architectural culture itself. Contrariwise, it is possible to see the mainstream projects principally focusing on large-scale or urban scale developments. The latest high-technology spaces of corporate estates of Apple and Google, for example, are also among the attempts of centralization of capital growth in the culture of architectural practice. Beyond some strategies of deterritorialization of informational society, the neo-capitalist development truly has a growth on the centralization, a territorialization of the information age's production environments. Thus, Silicon Valley can be regarded as the pioneer of the territorialization of the culture of informational motion as the site of high-technology corporations besides significant research universities.

Alternatively, the 'hyper-reality' of production spaces of motion can be surveyed under the competing paradigms of architecture compared to the mainstream spaces of production of motion. Regarding the virtuality between Objectile and Subjectile by the critical scrutiny of the capitalist mode of production, Hypersurfaces become entities to be discussed about the domain of architecture's current reality in motion. The twin projects of Fresh Water Pavilion and Salt Water Pavilion by Spuybroek (2004) and Oosterhuis, in that regard, best represent the new logical turn of architecture by digital tools influencing the manufacturing and design of space. The Fresh Water Pavilion by Spuybroek in particular indicates the paradigm of motion and flows of spaces and relations that Objectile constructs (Figure 4.12). The projects utilize the computational means to find new modernity under the principles of natural sciences with the freedom of mathematics and geometrical survey.

Figure 4.12. Water Pavilion, by Lars Spuybroek (Carpo, 2013b)

The interpretation of the reality of data assessed or accessed via computational means has also divided the approaches into two. On one side, the paradigms-in-paradigm shifts can be followed, for example, in parametricism (Schumacher, 2014), utilizing the abstract thinking of mathematics and geometry but only developing some virtual forms of experience. On the other hand, sensory environments and smart spaces directly correspond to the perceptual attachment of experiences of users in the strong and weak responses of environments in close consideration with energy relations. It is not here to directly favor sensorial environments utilizing embedded computation (Fox & Kemp, 2009) or self-sufficient sensorial systems and smart grids. Conversely, a synthetical solution regarding both functional and perceptual aspects of the built environment with all parameters would correspond to the rising and yet fledgling attempts in architectural technology in the existence of artificially intelligent systems and new computational means approximating to the experiences of humans.

Such an approach is initially experienced in Lynn's Embryologic House yet with limited potentials compared to the twenty-first century's technological possibilities. Kas Oosterhuis's simulative *E-Motive House* with movable elements also debuts as being the prime example of dynamic architectural spaces (Oosterhuis, 2014) that move as adaptive elements/environments with regard to the user demands/actions with the help of digital technologies (Figure 4.13). Additionally, his later '*NSA Muscle*' project gives one of the mystical examples that can predict user behavior and movement, and change its shape by mimicking convulsive reactions to open its gates (Figure 4.13).

Figure 4.13. E-Motive House by Oosterhuis (left and middle); NSA Muscle project (right)

It also becomes possible to discuss various applications and spatiotemporal agencies moving in the built environment, as in the case of Kilobots (2014) (Figure 4.14). Defining the built environment with the agencies of flows should be studied as a distinct domain of research in its dynamics.

Figure 4.14. Kilobots, 2014 (Claypool, Garcia, Retsin & Soler, 2019, p. 78)

The new desiring-machines even specify some zealous approaches and inspirational movements that become referable under specific names: Adaptive Environments, Interactive Environments, or Responsive Environments. It is possible to define all distinctive entitlements with respect to the degree of technological complexity and the abstract modeling of recognition they apply. Whether designed according to subjective or natural principles, or operating mainly through natural or artificial principles, the common share among the projects is bridging the gap between the subject-object interaction by considering the states of subjective choices and decision making. It is possible to report these new developments as alternative paradigms in architecture:

Interactive architecture/environments carry embedded sensorial mechanisms and process information as a stimulus coming from an external agent, the user subject. As "desiring-machines" (Deleuze & Guattari, 2005), they try to develop a usage pattern and learn the user's actions and his/her responses to the environment. The complex interaction by embedded computation and physical (kinetic) counterparts creates process-oriented dynamic spaces and objects that perform pragmatic and humanistic functions together (Fox & Kemp, 2009). Many projects can be found to discover the potentials of sensorial mechanisms in response to the behavior that is detected as a stimulus, like the exciting project '*Dynamic Terrain*' (Figure 4.15).

Figure 4.15. Dynamic terrain, accessed from https://www.nextnature.net/2006/06/dynamic-terrain/ (Left); Flare-kinetic ambient reflection membrane, accessed from http://filt3rs.net/case/flare-kinetic-ambient-reflection-membrane-130 (Right)

The project investigates an experience of topological connectivity between the tactile sense of the human body and the interactive agent controlled by a computational system processing data from multiple sources (Fox & Kemp, 2009). The interactive experience determines the development of a culture of architecture inspired by mathematical and geometrical explorations to influence further technological engagements and sensorial analysis. Although it is hard to find larger-scaled applications of such inquiries, the project ‘Flare-kinetic ambient reflection membrane’ (Figure 4.15), for instance, allows us to see the interactive façade articulation with respect to the light and ambient change in time.

Responsive architecture/environments respond to the user during the interaction; they aim to mitigate the energy consumption of buildings, as a performative criterion, via sensors, control systems, and actuators. The responsive environments (Perry, 2013) envision the responsive interaction of subject and environment to distinguish ever-evolving progress (Uçar Kırmızıgül, 2011) or the ecosystem. The projects entitled as responsive environments assess the subjects’ sensory-motor or emotional reactions and react to them by a series of algorithms learned by the artificial agent. The interesting projects ‘Farnsworth Wall’ and ‘Farnsworth Curtain’, realized by the same theoretician-designers, for instance, are precious in terms of their evaluation under the principles of the competitive era of production (Figure 4.16).

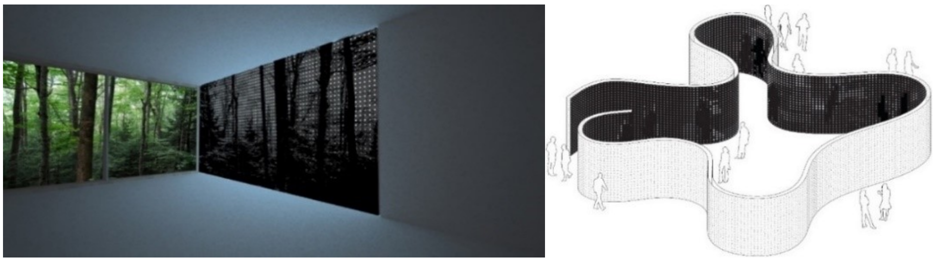


Figure 4.16. Farnsworth Wall, by Studio NMinusOne, Christos Marcopoulos and Carol Moukheiber with Mani, 2009, (Left) accessed from http://nminusone.com/wp/wp-content/uploads/2012/11/Farnsworth.jpg; Farnsworth Curtain, by Studio NMinusOne, Carol Moukheiber, and Christos Marcopoulos and Min Woo Kim, (2011) accessed from http://nminusone.com/wp/2012/11/24/farnsworth-curtain/ (Right)

The projects can also be seen as alternative developments relating to the crisis of the early professionalization practice of architecture, Farnsworth House itself, which was issued in the courts due to its privacy problems. So, the two projects also signify a response to the modernistic paradigm integrating new technological advancements that entirely change the static perception of the user as well as the designer. As a further evolution of the wall project, the curtain (Figure 4.16) responds to the moving agents around the surface so that the users may not interfere with unexpected actions.

PixelSkin02 project, IMBlanky, or Variable Geometry Truss represent other examples that are becoming the agents of motion since they can move or change shape according to external forces. They can digitalize the changing form either by embedded computational systems or by their self-sufficient features of materials. PixelSkin02 (Figure 4.17) was developed by Sachin Anshuman, and features the crystal structure of nickel-titanium alloys on façade as dynamic shape-memory actuators that can change shape according to electromagnetic and energetic contractions (Fox & Kemp, 2009).

Some projects such as IMBlanky (Figure 4.17) (Rodolphe El-Khoury & Marcopoulos & Moukheiber, 2012) actually boost an approach that makes the 3D topological form generation possible with hardware that is controlled by microcontrollers such as Arduino LilyPad and through software. Digitalizing the immediate condition of smart surfaces also enables the visualization of the topological forms as informational data. The 'Variable Geometry Truss' (Figure 4.17) (Rodolphe El-Khoury & Marcopoulos & Moukheiber, 2012), on the other hand, is a project that is designed under the loaded slab on top and includes force sensors on each connection point at the lower edges. The system immediately calculates compression and tension on members and moves and changes shape accordingly. The sensorial data is again controlled by microcontrollers (Paterson, 1980) as being ‘less expensive’ than other complex solutions.

Figure 4.17. PixelSkin02 project, nickel-titanium alloys on façade as dynamic shape memory actuators (Above Left); IMBlanky project (Above Right); Variable Geometry Truss (Below)

“Adaptive environments” can be seen as a further endeavor of the desiring machines just to develop an intelligent behavior with respect to the interactions and responses given to the outer environment (Lehman, 2017). The agent adapts to evolving or changing conditions and makes some predictions about future usages and changes. It can be possible to imagine the development of further smart spaces based on the systematic development of neural networks and artificial intelligence. These potentials prospect to question the integration of subjectivity of fuzzy systems with the developed self-sufficient materials at the nanoscale to come up with a level of complexity of intelligent systems. It also indicates the evolutionary process of intelligent environments and systems (Erişen, 2020a). The shared principles of matter and energy of subjects and objects have been used in such projects organized around the corresponding models of artificial neural networks and machine learning.

Regarding these examples, it may be possible to put forth that interactive and responsive environments have created a milieu of the paradigm shift in an established culture of making and theory by the dynamics of evolution and alteration in the architectural profession. It is also possible to re-evaluate these examples with respect to their interactive and responsive characters while performing, especially according to the different geometric paradigms of Cartesian or non-Cartesian approaches. It enables us to interpret that the projects can either be observed in Cartesian or non-

Cartesian geometrical approaches. While discussing the tactile senses to recognize/intuit the environment topologically, the systems carrying only tactile sensors are restricted to giving topological responses in the lack of visual data that is virtual to the experience. Nevertheless, it is possible to evaluate the visual data as formally robust and more efficient to develop projects giving topological responses.

Kas Oosterhuis's e-Motive House project (2002) is an example from which one can see the future of responsive topologies to decide on the sensorial and responsive experience of utilities and environments. Accordingly, the embedded computation itself can be seen as sufficiently versatile to coordinate rational or topological responses, though the visual sensorial data can be upsurged to harvest and explore the potentials of non-Cartesian features of architectural elements. To make this statement clear, it may be helpful to remember architectural elements of doors, windows, slabs, and walls as being parts of Cartesian geometry. When we identify the non-Cartesian geometries and their responsive simulations, it becomes impossible to decide on the fixed architectural elements but a blending fold of topologies into each other. From this point of view, the reality of 'embedded computation' is germane to our discussion of the control and coordination of the sensorial data and the environment's responsive character. The information age's revolution thus shows alternative oppositions that can be constructed by territorialization and deterritorialization of high technology.

Considering the larger-scale production of those territorialized spaces like urban environments, the current condition of effective moving agents, such as the Google (Earth) Street View Car (Figure 4.18), can be examined as part of a dominant production and consumption model. Just envisioning a novel kind of development, the moving urban agents remind the evolutionary place of information in our urban life (Mitchell, 2010) and signify a settled organizational schema of the crowdsourcing for urban computing by the internal dynamics of informational society. The example of CYSP I (Figure 4.18), designed by Philips Company and the artist Nicholas Schöffer in 1956 (Shanken, 2012), was similarly an agent for urban space, which is the first cybernetic sculpture in art's history that integrated artificial rules of automata studies. Having the name composed of the first letters of cybernetics and spatio-dynamics (CY & SP), CYSP I gives clues about the development of the culture of the artificial in experiencing the environment. The project simply enables the manipulation of the emotional atmosphere according to basic sensorial and perceptual scenarios, and participates in an autonomous action of motion. Accordingly, its use of dancing and moving sculpture in the special events proves its cybernetic design according to the developing self-reproducing automata rules that are integrated with sensorial means (Shanken, 2012)[112]. Accordingly, the system responds to the cold atmosphere of the blue color by moving forward, retreating, or making a quick turn and making its plates turn fast just to balance the mood. In the existence of red color, the sculpture remains calm, accordingly, as it is excited by silence and it is calmed by noise, or otherwise it is excited in the dark and becomes calm in intense light. It also keeps the statistical dynamics rational because 'if a dark line is drawn to create a closed space, CYSP I will not cross that line and keep its movements within that space'. The system can be accepted as the first attempt to hybridize a humanlike behavior with the artificial systems designed for an art agent. It shows the contractions between the natural/biological and artificial systems that have certain conjunctions and parallelisms, as well as the disjunctions.

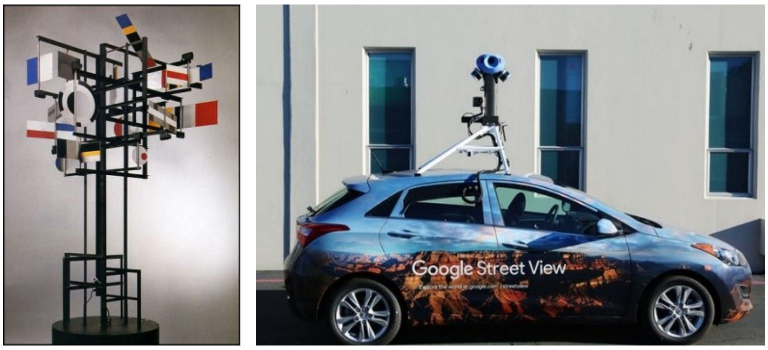


Figure 4.18. CYSP I (1956) by Nicholas Schöffer & Philips Co. (left); The Google (Earth) Street View car (in the second decade of the twenty-first century) (right, photo by Google via Wired)

As a proposal for the evolution of a development series of motion-based agencies from cybernetics to intelligent environments, the closer periods' informational development by the specialized agencies can be discovered as potential opportunities to create a productive character of the spaces of motion by the usage of Augmented Reality. Just

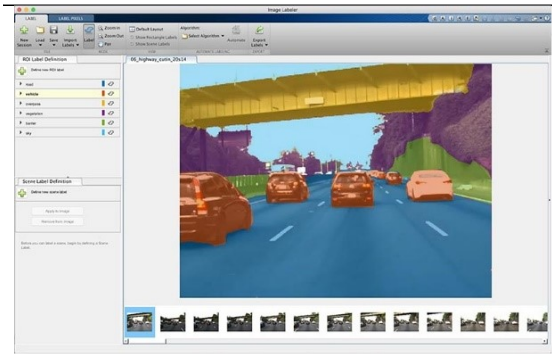
[112] See also "Practical Robot Circuits" A.H. Bruinsma – a Philips Technical publication. Accessed from: http://cyberneticzoo.com/cyberneticanimals/1956-cysp-1-nicolas-schoffer-hungarianfrench/.

as a strategy to develop a counter-resistant mode of informational development, mobile informational agencies' existence can be identified as opportunities to develop even particular yet collective power of architectural and environmental agencies of information and action. Nevertheless, they can be conditioned as if they can be used under the generation of specific intelligence. Starting to think about the possible potential of the Google Street View car, similar agencies can be envisioned as a part of exploration and design strategy. Wearable, moving, and portable technologies have the ability to document, visualize or digitalize the environmental forces as the strategic agents of design and collective activities, creating territorialization fields among the strings of flows. In that regard, it also becomes crucial to discuss the role of the built environment and the rise of new technologies in the crowdsourcing of environmental data. Wearable devices besides virtual reality (VR) and augmented reality (AR) are possible means to increase the prediction of user/occupant behavior.

The Smart spaces/grids in crowdsourcing: The energy efficiency in the intelligent spaces exists at the intersection between architectonic capabilities and the larger-scale urban computation. Thus, it becomes possible to discuss the role of neural networks and even neuromorphic computing chips in increasing the performativity and predicting user/occupant behavior for larger-scale considerations or under special conditions (mental illnesses, disabilities, considerations for older people, security, or productivity). Staying mostly at the level of smart house systems, it can be argued that the transformation of urban computing can be achieved by searching for the new means of technological applications as well as applying different methods and algorithms for optimized solutions (Pedrasa & Spooner & MacGill, 2010). In that regard, energy-efficient technologies (Shan & Hu & Guerrero, 2020) and the issues about the management of power and tariffs for its usage (Luo, Kong, Ranzi, & Dong, 2020) imply the necessity of smart grids in architecture. CO_2 emission rates, the utility of appliances and services in domestic environments, and connected domestic devices through the internet with resiliency in usage (Metke & Ekl, 2010) evoke policymaking parameters for smart grids.

With this idea, it is possible to explore the potentials of state-of-the-art technologies of the twenty-first century. One of the most influential and intense fields of research and exponentially growing field of professional study over the informational transformation of environmental factors is object recognition with the help of the latest versions of software solutions in the advancement of artificial neural networks (Ng, 2017; Erişen, 2018a; Du & Li, 2020; Shi & Qui & Ling & Yang & Yang & He, 2020). Immediate image segmentation or 'real-time' object recognition with the help of software solutions has been among the more popular performative and epistemological fields of research in the first two decades of the twenty-first century (Table 4.2). However, the inquiry towards the documentation and recognition of the built environment concerning the architecture and urban space is still limited. There can be found only severe examples using smart systems or certain advanced high technologies such as LIDAR (Table 4.2).

Table 4.2. Artificial neural networks and software solutions for real-time object recognition; MATLAB and LIDAR in the informatics of the built environment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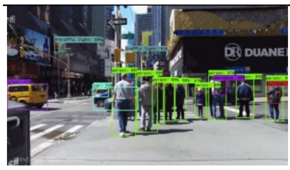
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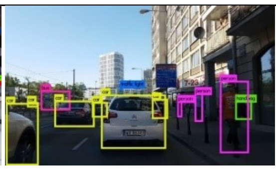
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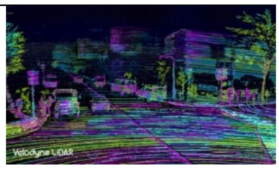
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1.Colored image segmentation, Internet: https://www.mathworks.com/solutions/deep-learning.html
2."Building detection and 3D roof reconstruction using multispectral ortho-imagery and LIDAR data" Internet: https://people.eng.unimelb.edu.au/mawr/BDetection.html
3.Deep Learning for Object Detection, Internet https://mc.ai/deep-learning-for-object-detection-from-the-start-to-the-state-of-the-art-2-2/
4.'YOLO (2&3) software' Internet: https://i2.wp.com/www.ideatovalue.com/wp-content/uploads/2018/04/yolo-object-recognition.jpg?ssl=1
5.LIDAR's real-time physical object recognition: Internet: ttps://blog.nobodydealslike.com/?p=6688
6."Velodyne & new LiDAR" Internet: https://www.engadget.com/2017/11/29/velodyne-lidar-helps-self-driving-cars-survive-the-highway/

The productive side of technological advancements has the advantage of generating informational knowledge in the perception of the environment. However, they are still restricted either to certain clusters of professional and marketing practices in the informational society or in the minority of certain academic research, or they are designed for the sake of special usages with cultural and recreational purposes. In the definition of the spaces of motion, the dominant technology firms and corporations, which are highly engaged with the major production and service shares of the global market of the twenty-first century, are still deciding on the direction of the 'evolutionary' trajectory. Nevertheless, the common distribution and infrastructure of the essential technological advantages through metropolitan areas creates socio-cultural dynamics of the informational transformation of spatiotemporal practices of urban environments, creating certain niches of collaborative spatial production opportunities for the decision makers and the organizational growth of intelligent spatial formations. This idea allow for the arguments for urban informatics and its place for defining the spaces of motion as a productive domain in the information age under the existence of multiple agencies of motion. On the other hand, the dominant agents of production and service should still be considered as the policymakers of the ideology of information.

Towards the potential growth of Urban Informatics and constraints behind: Urban informatics and urban computing can territorialize the dispersed production relations of alternative or academic approaches regarding the environmental and spatial integration of agencies as a creative reorganization. According to the discussion of societal spatiotemporal experience, urban informatics can be engaged with the potentials of information to derive a new mode of spatial production concerning architectural practices by contextualizing the flow of data to its users. It can produce niches of spatiotemporality by surveying people's predilection and their actual tendencies in urban environments. The hybrid architectural knowledge as feedback from the users and agencies of the built environment provides strong connections between the closed architecture culture and what social and cultural forces are demanding in the built environment through crowdsourcing and architectural technologies. It corresponds to the development of different sensorial and networked solutions such as the Internet of Things or Ubiquitous Computing. These are the twenty-first century's state-of-the-art technologies in the usage of common communication means. They can also be suggested for controlling the sustainability and environmental conditions as well as processing the fuzzy sets acquired from the social and cultural forces of people, which correspond to the significance of subjective justification on the physical built environment. The crowdsourced subjective data should be accounted for in transforming the spaces of flow into the orderliness of certain formal aspects of social and cultural features as identities of spatiotemporalities. Complex analyses and syntheses on the observation of spatiotemporal experiences and other agencies' discursive statements on the built environments can be classified as one domain of research. On the other hand, there should be the direct observation of spatiotemporal actions and environmental forces that are exempt from the reference systems of subjective interpretations to determine the strong correlations in evolutionary states.

Dealing with Big Data requires an informational mode of the spatiotemporal tendency of users/citizens. It also necessitates the internal evolution of a professional understanding of the city under the global forces of informational flow and motion in the design, regulation, and control of the pace of the everyday life of the city. As a convolutional problem for the growth of architecture, it cannot be seen as distinct from the originating forces and constraints and the internal potentials of the informational society that is embedded in its precedent spatial practices.

The Sites of High-Technology; The Spaces of Motion Territorialized: It is not accidental that the projects described until now have a closer history and yet are not even as new as the last model of mobile phones, computers, or other digital media of the information society at its 'core'. This term 'core' is precious again in terms of revealing the facts of information technologies that the mainstream companies such as Apple, Google, Microsoft, IBM, Intel, NVidia, AMD, and Hewlett-Packard hold a considerable part of the capital, and can control and manipulate the market as well as decide on the direction of technological advancements. However, the examples of sensorial environments have remained at the edges of the production of information or as a part of academic research, while these larger companies have also started to disseminate their smart home applications (Xiao et al., 2020). Nevertheless, high-technology giants still do not prefer to directly develop non-profitable or costly progressed development of hardware/sensor-based projects.

The sites of high technology have been organized mainly around the informational technologies to find their initial development in the war technologies of the USA in the 1930s, and then authentically in Silicon Valley around research universities, starting from the mid-1960s. Information technologies have been developed due to the inspirational forces of Shannon's information theory in the 1950s and brought the imagination of binary codes into reality (Shannon, 1949; Avery, 2012). While describing the revolution of information and its juggernaut technological advancements, it is compulsory to see this development as a smaller society of technological inventors, investors, and scientists of the twentieth century, with a considerable impact as becoming the reality of global communication and everyday life activity. It is the informational society (Castells, 1989) that designs the spaces for consumption of the ubiquitous becoming and produces their own territorialization, the sites of 'being'. As a culture and enclosed with a certain ideology and desire, informational society urges the construal of professionalization principles and its competitive aspects of positive and negative characteristics.

Apple's new campus, Apple Park in Cupertino, designed by Foster + Partners, can be grasped as the best example to see the pure attempt to territorialize this investment of technological development, with a desire to settle in a serene and peaceful landscape as a traditional culture of technology campuses (Mozingo, 2011). Looking from an ideological point of view, however, it may not be accepted as an inspiring form-concept but a mere toroidal shape of a new Panopticon[113]. The shape does not even eclipse the security considerations in the design decision on the building (Figure 4.19)[114]. However, it is not here to make any further cynical interpretation of the new mode of surveillance, inside and out. Respectively, the shape and scale of the building have control over closer spatial experiences, and represent a more extensive international control of production and marketing reflected on the spatialization practices as almost becoming traditional in its own informational culture.

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113 See also (Foucault, 1973; 1977; 1995; 2003).

114 Steve Jobs finds the outside perimeter of the facade of the Project as a continuous zone to feel safe in wellbeing. Accessed from Archdaily.com.

Figure 4.19. Apple Park, accessed from https://9to5mac.com/2018/01/14/latest-apple-park-drone-footage-shows-landscaping-final-touches-starting-to-take-shape/

The transformation of high-technology spaces/offices that are mostly located around Silicon Valley reveals the evolution of the offices from 'the corporate campus' to 'corporate estates' (Mozingo, 2011). The scale of the latest projects of Apple Park and Googleplex surpass these definitions further with larger functional project areas within the existing headquarters of many technology giants in Silicon Valley. What is more significant is their central position in the technological and economic development of territorial and global existence and their competitive differences as contradistinction even among themselves. There is a clear-cut and sharp distinction between the two different campuses, not only in configuration but also in the formal aspects of the buildings. Although the desire to settle in nature for relaxation as a tradition remains the same in both proposals, in the Googleplex project, it is evident that building blocks are blended into the landscape as a repercussion of the competitive approach, yet controlled with a utopian dome. The approach in Googleplex responds to the compact and unified design of Apple Park, having a central inner park. Inevitably, these business firms hire competing architectural groups in similar projects as a new epoch of professionalization. The reality of the competitive culture among Apple and Google is apparent that one company is hiring Foster + Partners for many projects, while the other company works with BIG Architects for the new development of working environments of professionalization. The other most considerable common share among the different sites of these technology giants is the familiar territorialization practices in the deterritorialized suburban culture of the United States. This fact perpetually repeats itself in the suburban pattern located near the inner side of the ocean and connected with highway networks; hence, it can only be accessed by cars, and includes vast car parking areas.

The territorialization practice of deterritorialization of suburbanization may sound contradictory in itself. The motion spaces resemble any idea of beginning for spatialization practices of energies and flows of something and possible immediacy in spatiotemporal experiences at maximum values. Based on the general and relative principles of energy and matter (Ballif & Dibble, 1969; Akhundov, 1986), it is also possible to envision spaces of motion in their territorialization practices either for the presentation of maximum values of energies and flows, or for a representative reflection of place-making as a result of the conditioned deceleration of that motion. Though the first is correspondent with the core of a societal organization of information societies, the second one can be seen as a strategic datum of deterritorialization that mitigates the capital's reaccumulation. Accordingly, the first one is directly akin to our discussion of the production of generative spaces of informational society that can be located at its core. The second is traditionally pertinent to any other stationary points of flows that can also constitute inevitable decentralization progresses. Airports, shopping malls, transportation hubs, and even hotels are such spaces that can be classified under this second expression. In short, the spaces of motion include a natural contradiction in itself, as directly connected to its source of generation and its exhaustion, or in other words, a tension between its production and consumption. However, many other hybrid spaces constituting the two can also be classified under any of these expressions. Just for this reason, Silicon Valley's own history and the strategic spatial dynamics trace the investigation about how such a pure product of the environment of the shared knowledge of high technology can also be seen as hybrid spaces of territorialization by locating itself at the core of these relations. This is why we can only see a very well concentrated capital accumulation zone and the new mode of production in Silicon Valley. Even though the region was constructed through a suburban culture, it is becoming a centralized region at the core of production and marketing relations (Castells & Hall, 1994).

In short, high-technology sites with living and production areas settle at the core of these relations with territorialization practices. The history of Silicon Valley and its rapid development is significant with regard to addressing the evaluation of the spatial and organizational features that have been realized at the core of the production and marketing relations of professionalization and competition in the information age.

The Story of Silicon Valley on the Strategical Territorialization of Professionalization:

> *"Silicon Valley has a guaranteed place in history as the original industrial core of the revolution in information technologies. While its reputation is based on the basic fact of concentration (in 1989) of some 330,000 high-technology workers, including 6,000 PhD.s in engineering and science, it stems also from the saga of Silicon Valley, hailed worldwide as a heroic model of innovation in the service of dynamic economic growth."* (Castells & Hall, 1994, p. 12)
>
> *"… the vitality and resilience of Silicon Valley over time and the achievement of its level of technological excellence were only possible because the Valley itself created social networks among its engineers, managers, and entrepreneurs, generating a creative synergy that transformed the drive for business competition into the desire to cooperate for technological innovation. These networks were constructed on these interrelated foundations: a work-oriented culture that valued technological genius and daring entrepreneurialism; professional organizations that sustained the centralization of work, residence, and leisure that became all-embracing of its own values and interests, while excluding and segregating other social groups and economic activities."* (Castells & Hall, 1994, p.28)

These statements may be satisfying to recognize the spatial-economic configuration of Silicon Valley, making a success story for many companies that create constellations of networking and synergy. Originally, Stanford University housed the Valley for the development; further, many other scientists, engineers, and other entrepreneurs have played significant roles, such as Hewlett and Packard, in the development of company campuses at first (Castells & Hall, 1994). Shortly, environmental aspects have strongly reinforced territorial development. Recent years' considerable investments in the condensed concentration of campus-driven spatial-social production have boosted the exponential growth. However, as described earlier, the spatial configurations only make a half-part of the desired aesthetic experiences for work, settled in a suburban nature. The culture of professionalization and competition, on the other hand, makes us internalize things clearly and even makes some suggestive differentiations between cultural projections in different spatial configurations. It is clear that beyond all of the desired settlements of centralization, Silicon Valley can also be seen as a demanding and tedious space for work, and yet this makes the Valley settle at the core of the informational relations.

It may be possible to classify some professionalization criteria about the culture of Silicon Valley to get contradistinction of extreme concentration with extreme differentiation. An ideological survey of subject-culture relations may have some suggestions with regard to spatiotemporal environments. Castells & Hall clearly enlist the interrelated features of 'Silicon Valley culture', making it at the core of informational relations of the professionalization. According to them, the centrality of work, opportunity for innovation, entrepreneurialism, aggressive competition, extreme individualism, the area's affluence, technostress, corporate subcultures, and compensatory consumption are the nine basic features (Castells & Hall, 1994) that do not require further investigation. The description of privatization as a closure against publicity and the critique of the concentric atomization making the enclosed utopia, *per se*, for determinability against the uncertainties can only be noted further as certain critiques external to the Valley culture.

In this study, it is preferred to analyze these features closely to come up with some new mode of suggested interactions since these features clarify the contradistinction of concentration and particularities and show the negative aspects of professionalization. The centrality of work, the affluence of the area, and entrepreneurialism, for example, make the Valley configuration concentrated spatially and performatively on certain things. The affluence of area among these may differ as being influenced by spatial design preferences yet require a certain concentration for work starting from the younger ages. Entrepreneurialism can be seen as somehow more flexible in finding much more individualistic opportunities, but the logical investments keep the core relations[115] focusing on the Valley.

On the other hand, corporate subcultures promote flexible matrix organizations (organized vertically and horizontally in the hierarchy), but they can also be accepted as a concentrating force for a larger corporate centralizing organization. It is a strategic organization schema that commutates between the concentration and particular opportunity for innovation, investment, and consumption. The more complex relations, innovation, aggressive competition, and technostress are just 'confluential'

[115] For the discussions about the organization of creative class and their relation to performative activity and to spatial (re-)organization, Florida's genuine arguments carry paramount importance (Florida, 2002; Florida, 2017).

cases resembling the 'fight or flight' struggle of subjectivity for the professional agent to decide on the performative tasks first. However, the ontological expectation on the work still represses concentration on duty. Accordingly, extreme individualism and compensatory consumption can just be regarded as the alternative character of the hybridizing Valley culture, and may prevent the Valley from being a pitfall of the horde culture. The additional aspects of privatization and eccentric atomization can only be argued as an external critique of the culture of suburbanization that still maintains itself as creating gated communities, blurred either through parkways or with the peripheral location of architectural designs distant from public interaction, creating an 'illusory utopia'.

It is also possible to explain the common culture in Silicon Valley with the recent construction of Apple's Technology Park and those of Google or Facebook that have yet to be constructed. Yet, they have the ideological differences resulting from competition in professionalization heading towards the spatial configuration in evolution, though the desire is to settle in nature in a suburban area, like 'negentropic anti-energy' for the demanding and stressful culture of work. Thus, the study searches the influence of the paradigm of informational professionalization, competition, and its learned behavior patterns with its shortcomings in spatiotemporal practices. This argument grasps a ubiquitous difference between the bucolic landscape and the enclosure of the building, between nature and culture.

Accordingly, the postwar development of American urbanization also engages high-technology sites as a product of cultural evolution (Mozingo, 2011), with a concern for the lifestyle of suburbanization to create new fields in serene and bucolic landscapes away from the congestion of cities, metropolitan areas. However, this is an ideological intervention of the capitalist ideal for the surplus-value of professionalization and competition in the new post-war age. This has either given young entrepreneurs a chance to become masters at the core service and industrialization of the information age, or still provides a segregated working environment settled in natural landscapes in contradistinction. It deciphers the evolution of suburbanization from cities due to capitalist investment with the desire for relaxation in nature.

Accordingly, Stanford Research Park itself can be followed as a gentrification area that started development in the 1960s under the university's control until the 1970s; and then turned into a landscape of technology that is harvested by neo-capital corporations (Mozingo, 2011). This progress makes us sure about the evolution of corporal settlements as a result of changing professionalization and competition that are reflected on spatial needs and their reorganization preferences. Mozingo's seminal classification makes a pure debut to get the exact literature of today's existing hybridized enlarged office parks. Even after analyzing the latest projects like Apple Park or Googleplex (Figure 4.19 and Figure 4.20), Silicon Valley reveals hybridized synergy in socio-spatial networks with existing residential settlements.

Figure 4.20. Google Headquarters at Silicon Valley, accessed from http://www.blueoakenergy.com/solar-portfolio/google-solar (Left); Googleplex by BIG Architects and Heatherwick, accessed from http://www.dailymail.co.uk/sciencetech/article-3109899/Google-s-tented-city-gets-taken-Firm-reveals-cut-plans-expand-Googleplex-giant-glass-dome.html (Right)

The earlier proposals in the formation of the Valley with living areas that included housing, shopping mall, and the university's research areas made the Palo Alto area located at the core of that hybridization with the accustomed historical trajectory in the evolution of corporal estates. The more controlled blocks of corporate estates (Mozingo, 2011) in the 1950s had a considerable place for compact solutions under competitive professionalization requisitions. Finally, the office parks (Mozingo, 2011) can be taken as the extended form of multiple office areas having a strong physical relation and a chance for social networking through open areas and other daily facilities.

Thus, it can still be restated that Stanford Research Park, Boston Route 128, and the Research Triangle Park can be recognized as the best examples of office parks trying to accomplish social networking in the new industrial developments (Castells & Hall, 1994). Regional developments such as Silicon Valley provide infrastructural reinforcements at the core of production and marketing relations. However, this does not change some shortcomings in the spatial-economical production and services of informational technologies. It is even more suitable to call those shortcomings rigidities that may not still be overcome by marketing and the dispersal of production and services. It is a tension between territorialization and deterritorialization that can best be understood by previously defined energetic relations in an abstract way. The stronger relations among the core of territorialization may not leave enough space to the alternative paradigms of described embedded computation in sensorial environments. The other reason also lies, however, within the type of product since the architectural and infrastructural productions require production-in-situ procedures. It becomes a problem of design in context, besides the lack of immediacy, in getting and processing the contextual information and, ultimately, a problem of the interconnection of multiple agencies in spatiotemporal experiences.

The mechanism of territorialization and deterritorialization in the spaces of motion by the logic of place-making is also about maximizing expectations around economic and social production. Accompanied relations of place-making for maximized profit and production constitute the core of informational spatiotemporalities. Accordingly, the spaces of flows at the periphery either make a field of alternative production environments or make a vast consumption area, deterritorializing larger energies and flows. Subjectivity and objective phenomenon behind these strong and weak interactions show the contradiction of territorialization and deterritorialization. This relation also reveals the polarity in problematizing multi-agent systems and globalized experiences of information society. The problem of multi-agency, respectively, will deal with detecting many agents on different sides of production and consumption of spatiotemporality. The strategy of generating the collectivity and intelligence among the multiplicity of design agents by creative crowdsourcing (Peters & Peters, 2018) can be seen as optimizing the problems of distribution of roles among the agencies.

4.2.3. Modelling the Behavior of Creative Agents of Design and Information: The *Problemata* of Multi-Agency and its Products

The distribution systems can be re-evaluated by the design of multi-agency organizations regarding the revised reinforcement of actor-network theory with regard to the discussion of ideology and desire from Deleuzian point of view. Desire and ideology may consolidate collective formation by human-artificial interactions to develop humanized solutions of artificial togetherness. Artificial neural networks like long-short term memory neural networks, or interaction models and communication technologies such as cloud computing and IoT, thus can be applied for the organization of multi-agents. This section will attempt to generate novel modalities based on the abstract relations between the creative agents of architecture and its technology regarding the scientific and cognitive research agenda on human-computer interactions and the relation of the architecture of creativity with futuristic modalities.

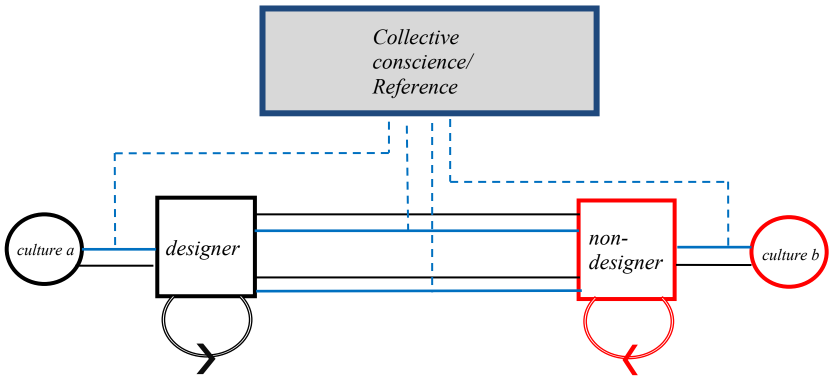
The novel modalities between Subjectile and Objectile and the new organizational levels define the spatial intelligence of the spaces of motion. Hence, the task is one of problematizing the multi-agency of the different sides of agents of creativity as they can either be subject and artificial, subject and subject, or artificial and artificial in production and consumption relations. On the other hand, they can either belong to the same professions or to environments, or make a hybrid-sharing environment by the difference between professions. Accordingly, one agent can be assigned as the designer, and the other can be an engineer (or engineered artificial agent), and one can live/work in university campuses while the other in the sites of high technology.

Respectively, the production relations via Objectile and Subjectile; and production of spaces[116] with respect to territorialization or deterritorialization play key roles in forming networks/ecologies of user and designer, practice and knowledge. Once the multiplicity of the roles increases, the problematique can only be defined/organized around the agents of design and around the roles of professionals as non-designers and social users. The scope of agencies also uncovers the leaders or decision-making masters on critical procedures, entrepreneurs, institutional and higher interventions

[116] See also (Lefebvre, 1991).

and, most importantly, the essential dynamics of increasing interactivity and responsiveness (Table 4.3) for the creative subject in correlation with (architectural) technology. The initial definition(s) of agencies are so significant to start problematizing strong and weak interactions and their outcomes with respect to their cognitive, organizational, spatiotemporal, and even epistemological aspects.

Table 4.3. Formal model of intelligence according to distributive systems of the multiagencies



The sensorial richness of the embedded computation still stands as an alternative mode of production in our daily lives and yet commonly emerges in house-automation or entertainment systems (Fox & Kemp, 2009), representing Objectile. However, their production does not have a strong impact in the creation of social intelligence of networking among the multi-agent production and consumption environments (Table 4.3). This is why the study proposes a critique with problematizing the core culture relations in informational society by bringing the discussion of creative subject and Subjectile together. The modality determines itself with a survey on the territorialization strategy of production and marketing as in Silicon Valley.

The different sides of agencies in the world of professional competition with their spatiotemporal actions and decisions reveal to us the actions of ‘performing’, ‘evaluating’, and ‘interacting’ according to the strong and weak relations. As we attempted to describe in the second chapter, however, this study tries to develop a mode of intelligence that can be applied through technology transfers among different sides of agents. According to this, the definition of designers and non-designers can set up a decision system on spatiotemporal actions to understand the problematique in the dichotomy of territorialization and deterritorialization of Objectile and Subjectile relations. Respectively, the design of territorialization can be one of validating the active role of the non-designer (for instance, the artificial agent) in the order of space with standardized rules of conduct that predicate over the design and the designer. On the other hand, the architectural world's alternative attempts may not envision inverse relations since most of the products and projects are under the control of well-engineered informational communication.

In brief, the study also tries to find possible correlation/synergy, between Objectile and Subjectile, between the human and artificial, between the designer and non-designer, as a mode of intelligence. At the organizational level, Manuel Castells and Peter Hall defend the 'synergy' that has been created around the sites of 'in-house' universities, and they focus on the importance of universities as a collective judgment over the development and progress of the organization. In that regard, it is even possible to claim that universities for the organization of such modalities between human-artificial agencies and Subjectile-Objectile relations in connection to the production and start-up companies through technology transfer can be the generic sites/interfaces for further progress and organization of creative agencies. Thus, the argument follows from center-periphery duality to the intelligence of creative organizations/environments of coalescence/co-existence of agencies that are busy with different performative tasks.

We have set forth universities as possible grounds for intelligent networking among the multi-agents against closed systems in their professional world. Just departing from this model of 'synergy', it is to rehearse the mindset of the informational age proposed not only to extract the adverse outcomes of professional competition but also to find some more practically intelligent solutions to mitigate the social and cultural infrastructures' expenditures. Respectively, subjective performance, collective responsibility, or conscience (reference), and social intelligence can be examined as the critical elements of discussion to criticize and suggest some mode of behavior/mindsets in analyzing the agents' positions and interactions (Table 4.4). Ideology and desire are so considerable to focus and decide on the behavioral and cognitive pattern of the agents of creativity and their intra-relations in organizational, spatiotemporal, and epistemological outcomes. These methodological elements constrain the suggestive critique only on what has been produced, and can be done critically as a futuristic estimation for those agents and their interaction. It is determined that ideology and desire's correspondent equivalences in technology can be questioned through classification and regression (or in biased states versus targets) in the recent development of research areas such as machine learning that can be further modeled by artificial intelligence and deep learning.

Table 4.4. One exemplar matrix of the strong and weak interactions among the agents (drawn by the author)

		agents of profession			topologies		
	mindset criteria &	designer	non-designer	social - institutional	responsive interactions		
general framework	content	subjective performance		collective conscience	social intelligence		
cognitive	attention & sensorial attachment learning rate & understanding memory imagination & creativity emotion & intuition determinacy & uncertainty reasoning & decision & judgment	1a	1b	2	3	I	ideology & desire
organizational	identity cost of energies networks communications	4a	4b	5	6	II	
spatiotemporal	territorialization & deterritorialization	7a	7b	8	9	III	
epistemological	scientific paradigms knowledge	10a	10b	11	12	IV	
modalities for spaces of motion							
relations : stronger >> weaker							

Similarly, each opposition, such as the culture-nature dichotomy, can also be considered on a more abstract level, even if they are not entirely commensurable[117]. According to this, classification is genuinely efficient to find some ideologically distinctive inputs, while regression marks a desire to progress and move forward for future expectations. Respectively, the different agents' actions can be interchangeably evaluated utilizing the established set of critique, ideology, and desire on the side of

[117] In the Table 4.4, the cells **I, II, III,** and **IV** represent the discrete and yet immediate relations among the modalities/durations. They cannot be linearly analyzed in the continuum of the interactions discussed this chapter.

creativity, and classification and regression on the side of its technology. Then, analyses start with the combinatory assessment of subjective performativity and their cognitive actions. A series of expressions are first set for both the designer and non-designer (or the artificial agents). The creative togetherness under specific references/iterations predicates an intelligent formation. Accordingly, the model proposes an exchange of skills and technology transfers (Fox & Kemp, 2009) between different agents (Appendix C).

Table 4.4 cell 1**:** What is imperative for the designer is to decide on the states of territorialization or deterritorialization in dealing with the data of accustomed habits, actions, conditions while being ideologically critical about the 'core' production and external inputs. It requires classification over the biased/ideological differences of external stimuli by looking at the long-term memory of the culture[118]. On the other hand, desire should be maintained to produce an ultimate 'product' around maximized expectations (Table 4.4 cell 1a).

A bias-free classification can help the non-designer to accomplish his/her/its role in the production of territorialization on its own culture/dataset for further regression. The transfer of skills and technology should dwell on the produced data to be classified following the skills of creativity, attention, sensorial attachment, and evaluating emotional actions and responses (Table 4.4 cell 1b).

Table 4.4 cell 2**:** Skill and technology transfer between different agents, the collective assessment as a judgment over the logical iterations and their ideological and emotional outcomes, respectively, become significant tasks (by affective computing, for instance). Collective conscience/reference's task can be generating the adaptive set of logical iterations on the set of the truth of culture for the desired outcomes of performance, the distinction of emotional outcomes, and to find the dynamic balance between production and consumption, territorialization and deterritorialization, ideology and desire (Table 4.4 cell 2). However, the collective conscience/reference should not be designed as an active agent and can only be modeled under a networked environment that can be called 'spatial or social intelligence'. Then, it is possible to

[118] The logical iterations of the other (non-designer) provides a training set for the architect to develop his/her own critical iterations over the decision of the end-product. See also (Courtland, 2018).

envision such a collective formation that can only override its own reasoning over networked communication.

Table 4.4 cell 3**:** The discussion needs to be expounded further about the formal and logical elements of social intelligence, which can either be an environment for the exchange of skills, data, or intelligent spaces, or otherwise create novel social and spatial environments for futuristic predictions and topological relations. Formally, it can either be a model of a neural network related to organizational and spatiotemporal aspects in cognitive modeling or psychophysical experiments or development for biological, spatial, and psychological models, which require the exchange of skills/mindsets and information. This modality describes a model of '*entangled connections'* among different users and networks so that one output can be an input for the other. Constructing such modeling requires defining the existing feature-based long-term memories (of experience and actions), sensorial systems, and logical reasoning processes over the historical and immediate data (Table 4.4 cell 3).

The feedforward and feedback mechanisms (or systems) are strongly required to control the overriding social-collective judgments (Table 4.3). Non-designer's precedent logical iterations re-evaluated according to humanized technology, would be a feedforward mechanism for the designer to initiate some logical iterations. On the other hand, it becomes an internal task for the designer to classify his/her long-term memory and the external products. Then, the designer's sensorial, emotional, and intuitive evaluation would be the desired input in a feedforward mechanism for the non-designer, which activates the agent for the task of classification (Table 4.3).

The initial classification of the non-designer creates a feedback mechanism. Once the data has already been classified, it turns into a regression task over the transferred secondary inputs (Table 4.3). The second input for the designer can be assessed according to the memory/culture and the proposed logical model; it can be classified and transmitted as feedback for the non-designer (Table 4.3). Additionally, the desired output, shaped with a future input from the other agent, will be a regression task for the designer (or its artificial agent). A collective conscience/reference should be present in further communication steps and can be judging over some possibly misleading feedback to provide the ground truth (Table 4.3). Once the secondary loops have been completed, the non-designer should perform classification tasks on the future product that may not even be released but regressed. It is such a compulsory activity for humanized technology that the non-designer should be truly critical and classify the other side's data. Since this can also be realized in the existing conditions of fast-production, or in the release of informational knowledge and product, one step more for the side of non-designers can be seen as a real task to start with intelligent modeling of socio-epistemological realms (Table 4.4 cell 3).

Table 4.4 cell 4: The agents' organizational behavior requires a critical positioning among themselves and matching with other professional clusters. Identities and commonalities can adjust this aim to accomplish a social exchange with other organizational principles and socio-economic identities (Table 4.4 cell 4a & 4b). In addition to the generation of hybridized pools of memories, one must also be ideologically critical about the cost of production of himself/herself/itself as criteria to communicate with different clusters. Once the cost of the nominal value of computational energies or the investment to the 'material energy' could be equal or lower than those of the closed circle of the performer, the social, cultural, as well as informational exchanges of data, products, values, and meanings of identities become inevitable (Table 4.4 cell 4a & 4b). Accordingly, a sustainable technology transfer model can be promoted for a social exchange under the coordination and judgment of collective responsibilities. The role of social and institutional organizations outweighs performance in organizing energies and identities, even if performance is essential in minimizing costs and maximizing the energies of things and subjectivities. This is also related to the preservation of institutionally determined identities, goals, and missions that should not be totally compromised with opposing circumstances.

***Table 4.4 cell 5*:** The distribution of the roles and information among the classical loop of organizations and agents requires the economic and spatial environments for human infrastructure. As a collective dynamic between the designer and non-designer, it is also prominent to define codes, conduct, and ideologically responsible circumstances for institutional responsibilities. It supposes a task to regress over a future code/values that are transformed among the strong relations in creating social intelligence of environments (Table 4.4 cell 5). A necessarily critical step here actually decides on the energies of interactions and the consequential aspects of institutional missions for interconnecting agencies of investigation, investments, and implications.

Table 4.4 cell 6**:** In organizational interactions, one should first generate an authentic set of values, memories, and identities, and specifying a dense **code of identity** is reasonable as a first step; otherwise, it becomes meaningless to interact with other clusters, as codes of identities would characterize the predetermined automation of things and energies (Table 4.4 cell 6). Differences and the hybridization of production and consumption relations portray the *problemata* of spatiotemporal experiences of agents and societies that are engaged in the flow of energies and deterritorialization of things. The contradistinctions, however, promote a new set of tasks to be exigent for the recuperation of the undesired outcomes, or gentrification and growth.

Table 4.4 cell 7**:** The related clauses among different agents can be decided after a set of interactions. If the designer had a problem of deterritorialization to be territorialized, he/she should process a generative rule of coding pattern[119] for the desired outputs. This can be described as a hybridization of place-making to design a production environment integrated with a habitat of living, economic, and socio-cultural growth. This task signifies an ideological gaze towards deterritorialization while requiring an expectation upon the environment's territorialization by the design activity. Another issue is the regrowth of a truly territorialized environment or a dispersal from the core of relations, as deterritorialization. For instance, Silicon Valley's growth around the sub-central organization of hubs can be the desired output for the designer to plan deterritorialization (Table 4.4 cell 7a) (Appendix C).

On the other hand, the non-designer should focus on sensing the problems in territorialization for integrating sensorial experiments with the immediate environment. It requires the imagination of the enriched environments with sensorial systems and smart spaces adapted to naturally responsive patterns (Table 4.4 cell 7b).

Table 4.4 cell 8: As a generic discussion, the dichotomy between externalism and internalism can be seen as a dissolved contradiction under the joint survey on subject-object interactions through territorialization and deterritorialization. The dynamic

[119] See also (Alexander, 1977; Akın, 1986; Mitchell, 1994).

interactions of identities and energies can be controlled and evaluated by collective conscience to generate novel themes of culture-nature togetherness (Table 4.4 cell 8).

Table 4.4 cell 9: In a design problem, collective conscience/reference can judge the configuration of a territorialized core of culture-nature togetherness. The decision can be about culturally cultivating the usage of the natural landscape integrated with the urbanized and socialized infrastructures, such as paths, artificial platforms, and social hubs. On the other hand, solutions can be integrated into the buildings tectonically. Respectively, collective judgments can create a design-decision protocol to find dynamic balance among the different experiences and cultures between the truth of definite rules. Then, the conduct of social and economic identities can be reorganized according to the judgment of the existence of collective conscience/reference in the topologies of humans, technology, and nature (Table 4.4 cell 9).

Table 4.4. cell 10: In the design environments, it would be novel to think about the agents' role in the creation of interdisciplinarity knowledge. Diagrammatically, there can be found some attempts to theorize superposition and disjunction of geometries, as Bernard Tschumi experimentally does (1994b; 2000; 2004; 2010). He founds exchangeable concepts to find the inverted relations, even between different reference systems. One can argue that the contradistinction between the Euclidean and non-Euclidean approaches is the most hotly debated issue in the field of architecture. It is not here to suggest, however, to find a mutant commensurability between the two because it can be truly said that non-Euclidean intuitions are already among Hilbert's axioms of relations: order, incidence, and congruence (Hilbert, 1971; Rosenfeld, 1988) that are discrete by the fifth postulate.

The assessments of psychophysics or experiments evaluated by sensorial assessments also indicate different paradigms. Accordingly, the designer's cognitive task can be deriving experimental findings from his/her psychophysical actions, and responding by concerning sensory evaluations for different epistemological outcomes. On the other hand, the task of the non-designer can be to deal with sensorial evaluations in-depth analysis and the phenomenal truth behind the depth of the sensorial experience to be compared later with psychophysical concepts. By assigning different agents either to performance-based or appearance-based assessments, it can then be possible to get a working associative learning model (Table 4.4 cell 10a & 10b) (Appendix C).

Table 4.4 cell 11**:** The mission of collective conscience is always to check the reality, reliability, and truth of experimentation. The task is about detecting and evaluating the noisy coincidences and errors while not interfering with the primary and secondary interactions of different agents and data. It would be possible then to develop a scheme, a growth of different interactive research fields while even not encountering, exhausting, or destructing the classical interactions (or paradigms). The specialized task of collective conscience in specific scenarios will be searching for alternative sets of interactions that can be tested on a network of knowledge generation and sharing for the generative technology transfer projects (Table 4.4 cell 11).

Table 4.4 cell 12**:** Epistemologically, the development of interdisciplinary fields can be expected as the desired output of the strong and weak interactions of the agents of identities and energies. Minor contradictions between psychophysics and sensorial evaluation show the gap between representations of objects to our senses. However, the proposed projects for exchange do create hybrid data pools of experience and memories that either be evaluated with psychophysics or with sensory evaluation. Although it is not possible to think about a unified theory on subject-matter relation, this prospects for new discussion sets. This inquiry may generate novel relations of 'Spatiotemporal Computing' of the future, expecting a novel direction in the development of theoretical and architectonic realms (Table 4.4 cell 12).

The architecture of creative evolution, respectively, promotes such alternative networking explorations among the agents of socio-economic and spatiotemporal actions for new common grounds to progress. Yet, there would be an expected outcome to deal with some unexpected errors and symptoms undiscovered in the classical layers of the competition of paradigms or professions. However, creativity by contradistinction defines itself according to this dynamic, and 'creative' evolution cannot be directly discovered in the already experienced, but only in the continuum of strong and weak interactions of various agencies and references.

4.2.4. Concluding Remarks

To construct an intelligent environment for the different agents and interactions is such an important task to consider architecture in an evolutionary progress. The togetherness of the logic of designing dominant elements with new generation computers of the spinning forces does regard energies, entropies, and identities of informational grounds. Imagining a survey of culture-nature togetherness in the integration of abstract systems of new technological progress is attached to a similar interpretation of adaptation. A generation of knowledge can only be derived from those strong and weak interactions in social intelligence environments, including the creative subject of architecture in correlation with its technology. The interactions for the desired outcomes can promote concrete solutions of technology transfers among the agents of identities and energies. It can be argued that in the exchange of different reference systems of production and knowledge of territorialization and deterritorialization of motion, the hybrid solutions in modeling the behavior (Thomsen et al., 2015) (Appendix C) may give concrete results of evolution and development on the same axis of ideology or desire. The difference between the spatiotemporal practices of Googleplex, Apple Park, or the architecture of embedded computation, and the universities, for example, still imply such an exchange of development of skills, technologies, and knowledge via relations of Objectile and Subjectile.

It would then be possible to talk about the architecture of progression and precession with intelligence to be formed around the evolutionary and systematized missions. Organizing energies and identities will be the art of the new era in the harmony of strong and weak interactions for inspiring grounds of differential evolution of experiences. The contradistinction of any novelties would decide on the creative dynamics of this new age. The transformation of those energies into the built environment can thus also be found in the alternative approaches of urban informatics, in spatiotemporal dimensions, and the search for novel multi-agency systems to reassign the roles of subjective experiences.

However, the discrete multiplicities of agencies scrutinized in the continuous motion and action still reveal the complex and creative modalities that call for the togetherness of the Architecture of the ‘Discrete’ and ‘Continuous’. Hence, the attempt is to modulate those modalities as well as simulate them via the non-linear complexities of ‘entangled connections’ throughout the thesis. Nevertheless, this belief can only be understood by fully discovering entanglement in non-linear or complex connections or fluxes of space-time, which calls for the challenge of measuring actions. The motion of (states of) nodes and networks necessitates further comprehensive investigation of novel and syntactic research for their features and singularities, to be analyzed in the following sub-chapter regarding the constructed modalities.

4.3. Bioinformatics and Swarm Intelligence in Architecture

4.3.1. Introduction

The role of creativity in the togetherness of novel artificial means, feature-based identities, and agents in action challenge quantification of the quality of emergence of things at their ubiquitous action that concerns the uncertainty of classical measures. Therefore, this sub-chapter explores the radical possibilities of new design and manufacturing processes with systemic rules at all levels of organization and production. Accordingly, the current research fields of ‘bioinformatics’ and ‘swarm intelligence’, as well as new manufacturing techniques of robotic assembly or ‘self-assembly’, are checked with informational potentials and advanced algorithms of metaheuristics. In the field of architecture, those themes are explored by way of designing and production through certain examples of significant figures at work. Kas Oosterhuis’s Water Pavilion, or Achim Menges and his team’s design and construction processes in ICD/ITKE Pavilions as in Landesgartenschau Exhibition Hall, for instance, mark the initial influences of the logic of digital manufacturing and robotic construction. Respectively, this subchapter analyzes new conceptual bases and coherent concepts for emerging complexities in practice and theory, like 4D printing, new construction, and crowdsourcing techniques, and particular content and discussions on ‘*Robotic Building’* (Claypool, Garcia, Retsin, Soler, 2019).

Until this sub-chapter, the paradigmatic turns of the creative evolution of architecture in the age of information and the dynamics of quantum bases have been classified into the fields of duration(s) of emergence and motion(s) of fluxes to be creatively synthesized (Hoorn, 2014). Thus, this sub-chapter is in the interest of two different fields of research in particular: (I) bioinformatics for genetic algorithms and adaptation of character (as DNA in biology and its production progress via RNA); and (II) the discussion of swarm intelligence in the analysis of collective (as well as particular) behavior detection and adaptation of behavior as a part of intelligent action. In the 'profession' of architecture, these dynamics can be observed in the emergent literature on nature-inspired research over the 'materialistic sciences' of genetic or evolutionary algorithms that are also encompassing the motion analysis in the existence of robotics, network organizations, and communications. The weight of the mass, feature-based identities, qualities, or representations are ensembled together with motion-based locational, positional, or energetic field localities that can be measured as the states/phases of the objects/subjects (like density operators of things) in action. Briefly, the related parameters on abstract models should both be based on:

- Weight, mass, feature-based qualities, identities, representations, and
- Locational/positional, or energy-based phases; the states of the things in action

These parameters are also supposed to apply a new logic of informational abstractions in the order of complexity of metaheuristics and advanced dynamical evolutionary algorithms with regard to the common bases of natural and artificial grounds of information such as PSO, QPSO, and hybrid-QPSO. The study attempts to find overarching schemata to scrutinize the persisting problems of evolution for the new logistics of Subjectile-Objectile modalities and artificial-natural togetherness for abstract crowdsourcing models to be applied for collective and intelligent spaces.

Regarding the progress, Objectile then can be based on these new inquiries. The sophisticated aspects of 4D printing by material-based considerations and motion of the filament in action by direct interaction with the environment include a similar multiplicity of various parameters in a reciprocal modality other than a relentless distinction between the emergence of matter and its kinematics. Following the two precedent sections, this section is designed to review the 'collective complexities' of architectural topologies of human-environment-technology with the accompanying Subjectile and Objectile relations. The newly introduced experiences of human-computer interaction and production practices in architecture need conceptual elaborations for further spatiotemporal and epistemological outcomes.

Regarding the synthetic relation between the artificial and natural, the chapter argues that the architecture of evolution cannot be a part of the traditional contradiction of different bases (Flachbart & Weibel, 2005). This sub-chapter puts the problems of synthetic reality in between the space and subject, the mechanical rules of life, and the relations with species and cognitive subjectivity. Subjectivity is thus to be identified with spatiotemporal endeavors of possibility and the sensual world in the progress of perception, learning, understanding, memory, remembrance, and decision making by feature-based tracking of spectral values. In that regard, it also becomes possible to evaluate the togetherness of human-artificial interaction and correlations with reference to Hebbian learning and Markovian decision-making[120] and the rise of new computation technologies such as neuromorphic chips.

Such research increases the possibility of understanding the immediate creative synthesis among the natural and artificial systems within intelligent spaces. The growth of 4D printing interfaces is also open to new interactive processes by crowdsourcing and the Internet of Things to design, estimate, and receive feedback from the interactions or even by means of AR, molecular computing, and synthetic biology simulations in unique environments. In short, the chapter attempts to analyze the particular contents that are apparent in some seminal works such as ‘Robotic Building’ according to the aims to derive conceptual argumentations, abstract thinking, crowdsourcing, and decision-making models to be applied for new Objectile-Subjectile relations. This can be seen as the aim of distributing the spatial (intelligence) practices looking for reterritorialization of the problematique between territorialization and deterritorialization and between Subjectile and Objectile. Distribution of new roles of agencies is the other aspect of the study that looks for the radical potentials of the togetherness of multi-agencies towards many-body systems of the artificial and natural. Accordingly, the chapter studies new organizational forms

[120] See also (Simari & Parsons, 2011; 2015).

of collectivities via '*Creative Crowdsourcing'* for data processing and decision-making models for intelligent environments (Peters & Peters, 2018).

4.3.2. Nature Reviews Architecture

Evolutionary reflections and projections of morphogenesis and the digital media in architectural practice (Oxman & Oxman, 2014) are extensively inspired by the field of bioinformatics. The place of 4D printing has recently introduced the ecology of the material-environment togetherness and the accompanying information processes towards the emergence of molecular collectivity (of polymers) and respective chemical and physical applying forces or biochemical/biophysical reactions (Figure 4.21). Respectively, it becomes crucial to regard the synthetic fields of research such as bioinformatics and swarm intelligence rules to ensure a comprehensive understanding.

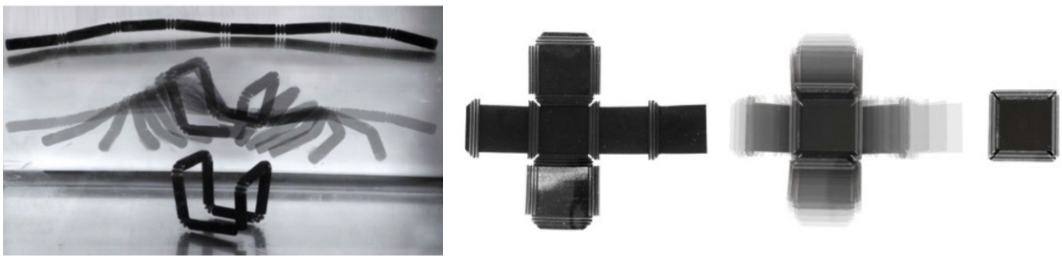


Figure 4.21. 4D printing of/by Hilbert Cube, 2013 by Skylar Tibbits and MIT Self-Assembly Lab, (Tibbits, 2014; Tibbits et al., 2017)

Another professional concern over the growth of production is the scalability of such kinds of novelties in the practice of 'smart' or 'Robotic Building' (Claypool, Garcia, Retsin, & Soler, 2019). The rising research from the smart grids and design of singular elements of dwellings towards automation in production can be seen as extended to the scale of urban environments, defining a phylogenetic transformation. This can be accepted as a substantial vision for the emergence of certain spatial intelligence with the provision over the sensorial infrastructures to imply how a spatial intelligence can still be established, even though there can be the reductionist mode of relations among the cross-relational aspects of nature and information. It should not be forgotten that the concept of intelligence, which is imagined on this active and widespread network, has a meaning that is scattered on the concept of deterritorialization to discover the phylogenetic evolution of the dynamic flows of certain energies. Thus, the concept of intelligence also illuminates questions about the generation of evolutionary intelligence and distributive systems, such as swarm intelligence.

For this reason, this formal-weighted discussion that is examined in bioinformatics will lead to new research within the concept of swarm intelligence, and will provide answers to the previously mentioned deterritorialization problems with new realities. Bioinformatics, first named by P. Hogeweg and B. Hesper in 1970, has a meaning parallel to today's biophysics (the study of physical processes in biological systems) or biochemistry (the study of chemical processes in biological systems) (Bioinformatics, Wikipedia, 2020). Dealing with evolutionary genetic algorithms and the adaptive growth of cellular generation in the forms of population that is based on the logic of cellular automata, the field of bioinformatics (Bioinformatics, Wikipedia, 2020) is crucial to focus on the closer analysis of organic orderliness and the extracted informational data. It is yet the interference of statistical analysis of the information that is acquired from the sequences of genetic material, like DNA sequencing. Even though Lynn criticizes technology's instrumentalization based on the reduced natural rules, the usage of the informational bases of evolutionary and genetic algorithms still corresponds to practical and scientific investigations enabling the parameters of computational logic as topologies. Bioinformatics points out an undisputable evolution of interdisciplinary research from materialistic sciences to computational and statistical research that are beginning to be vigorously applied in architecture.

Furthermore, just to briefly describe, ***Cellular automata*** was pioneered by von Neumann and used to develop schematic design thinking in architecture and cognitive sciences. ***Geometric metamorphosis*** is even a somewhat familiar term that is highly involved in the art, design, architecture, and planning used to express the emergence of the orderliness of patterns in the intuitive forms of geometry. ***Genetic algorithms*** are common, especially in the cross-over of variations that belong to different agents. In theorizing hybrid spaces of the built environment and conceptual design, genetic algorithms play a crucial role in carrying out the feature-based information of each cultural and materialistic inheritance (Sargın, 2004). Lynn also uses evolutionary genetic algorithms to produce an envelope of his *Embryologic House* with regard to the adaptive parameters of living, lifestyle, climate, functional usage, and aesthetic considerations (Lynn, 2013). Inspired by biological evolution, ***evolutionary algorithms*** define the domain of mathematical reiterations on the evolutionary variables and parameters of metaheuristics and nature-inspired algorithms in a constant change in population-based optimizations (Appendix C). Evolutionary algorithms use mechanisms such as reproduction, mutation, recombination, selection, and adaptation as a learning process by defining the 'environment' and its entities/agents with/as 'problem' and parameters (Iba, Noman, 2012; Iba, 2013) (Appendix C). Further studies under the similar concepts of evolution, means of evolutionary computation, and information systems are:

- Soft computing on creative adaptive algorithms and neuro-fuzzy learning (Rutkowski et al., 2014; Kim, Kobayashi, Kim, 2014; Aleksendric, 2015);
- The self-assembly systems at the scale of nanofabrication;
- The nanobiological (like photosynthesis) informatics with computing, communication, and production

As another significant research domain, Craig Reynolds (1987) generated the term 'swarm intelligence', which is the collective behavior of natural or artificial agents as self-organized, decentralized systems. Since Gerardo Beni and Jing Wang introduced the conceptual expression in 1989 in the context of cellular robotic systems, swarm intelligence has also been applied in artificial intelligence (Swarm intelligence, 2020) (Appendix C). *Architecture of Swarm Intelligence*, in that regard, can be seen as an excursion of the novel possibilities that are deterritorialized under the dominant forces of artificial logic, informational production, and consumption. Swarm intelligence points out physical and biological phenomena and even non-linear network structures in the production of information. It is possible to talk about the intelligent network structure and logic system that Kas Oosterhuis offered at the beginning of the twentieth century by the Swarm Architecture concept (Oosterhuis, 2006). Oosterhuis also describes a field of interaction and information generation throughout the buildings and environments by the flocking behavior among the components and agents:

> “Flocking behavior applies to particles systems at any scale, it applies to home appliances, furniture, buildings, and cities. Although explicitly seen by him as a metaphor, the book Quantum City written by Ayssar Arida in 2004, gives us some valuable clues for the importance of further research on the quantum-like behavior of complex systems like cities. Arida discusses world views of great civilizations, quantum theory, uncertainty, interference patterns, eventually proposes the new term diventity, which is a conglomerate of diversity and identity, and states that we must adopt now to the world view of General Relativity and Quantum Theory.” (Oosterhuis, 2006).

The corresponding inquiry includes the autonomous and decentralizing agents of building or construction components to be simulated as the ecosystem of robotic fabrication and construction agents (Figure 4.22) by getting inspiration from nature (Oxman, 2015; Melenbrink & Werfel, 2017; 2019). In that regard, networked agencies are also supposed to be trained with regard to the geographical and environmental analysis of an unknown field in modeling spatiotemporal complexities (Yiannoudes, 2009; Ghnemat R., 2009; Ghnemat, Bertelle, & Duchamp, 2008a; 2008b; Menges et al., 2019). It makes sense in the unpredictable and uncertain conditions throughout the excursions on developing the scientific programs, synthetic logic systems, the mathematical bases for the abstraction of relations of energies and identities corresponding to the entropies of information.

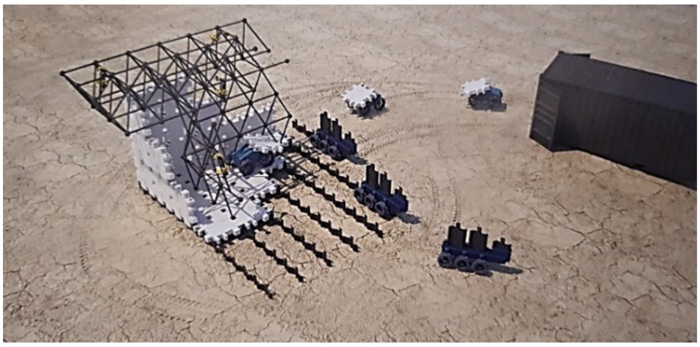


Figure 4.22. Ecosystems of robotic fabrication and construction agents, Nathan Melenbrink (2017)

Swarm intelligence also implies a significant leap in the professionalization practices and conventions in architecture and a major shift in the whole logical system of designing and defining the emergence and processes in a completely different way. The experience in the Water Pavilion project, for instance, has challenged the conventions of the contemporary way of drafting in the 2000s. Oosterhuis says that once their design team visited the construction site at Neeltje Jans in Zeeland for the *Salt Water Pavilion,* they could only be able to run the CNC production system by the scripts and processed informational data instead of the CAD drawings. This revealed the fledgling universality of parametric algorithms' new logic in automation, production, and construction (Oosterhuis, 1998) (Figure 4.23).

Figure 4.23. Salt Water Pavilion and Hydra sensorium, accessed from http://onl.eu/projects/salt-water-pavilion, on 12.12.2018

Following Oosterhuis's seminal ideas and practices on Swarm Intelligence and Architecture, Socrates Yiannoudes has developed "Swarm-roof project" (Yiannoudes, 2009). Yiannoudes's attempt focuses on swarming the dynamic movement/motion of tectonic elements controlled by autonomous robotic systems. Agents are organized with the swarm intelligence principles that update the configuration of the pattern among themselves with respect to the evolving distance states (Yiannoudes, 2009).

As an enthusiastic example, exploiting the potentials of 'embedded computation', Shadi Ramos's project, 'Swarm tile', can be given as an alternative approach for smart spaces having genuine potentials of swarm intelligence in crowdsensing (Figure 4.24). 'Swarm Tile' makes it possible to communicate with architectural elements among each other and potentiates for a responsive environment by influencing and being affected through multiple-agent systems (Rodolphe, Marcopoulos, & Moukheiber, 2012). It further enables 3D topological approaches and mandates for an adaptive environment that is connected to closer environmental forces.

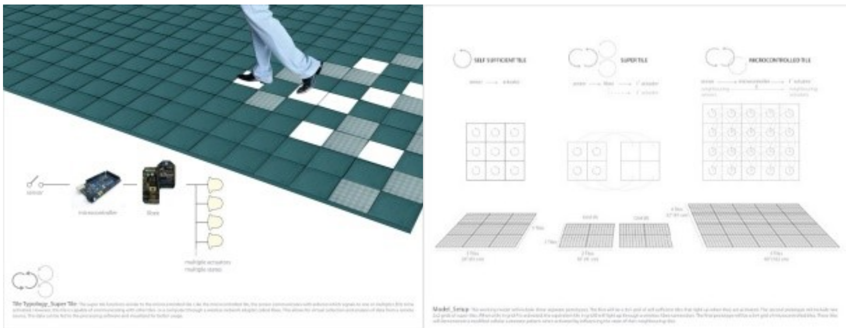


Figure 4.24. Swarm Tile by Shadi Ramos (Rodolphe, Marcopoulos, & Moukheiber, 2012)

In addition to the metric update among the organization of agents' collective behavior, it is also possible to generate certain adaptation-based algorithms under similar approaches inspired by swarm intelligence. In another research effort by Ghnemat, Bertelle, and Duchamp, the team aims to generate an intelligent pattern of agents that can adapt to the environment with particular ecological dynamics in principle (Ghnemat R., 2009; Ghnemat, Bertelle, & Duchamp, 2008a; 2008b). Respectively, the organization can get geographical information, and applies ant colony-based algorithms (Ghnemat, Bertelle, & Duchamp, 2008b) in the construction of artificial ecologies that can self-produce with respect to the learned conditions by foraging. It can be seen as an efficient way of modeling the environmental forces, dynamics, and configurations in design progress that is unknown to the centralized decision-making systems, as the research team explains the merits of the study exploiting geographical information systems (Ghnemat, Bertelle, & Duchamp, 2008a).

It should not be forgotten that the most crucial feature of the swarm intelligence in this study is to extract out abstract principles to decide on a complex and evolving pattern of motion. To solve deterritorialization problems of a central system, swarm intelligence gains priority in the necessity of decentralization of an intelligent system to be organized again in a high degree of uncertainty. As in Kas Oosterhuis's seminal interpretation, the algorithms and methods of swarm intelligence define a multidisciplinary research domain that enables various assessment techniques due to the natural-artificial togetherness in abstract and creative logic. More straightforward decision-making steps are further explored by hybridizing dynamics and static modeling among bioinformatics of morphogenesis and swarming to optimize the problems of adaptation of particular behavior by learning from environmental forces to create complex decision-making models and geometric orderliness. There are creative studies, for instance, regarding the web of spiders as the membrane-like structures/filaments to observe the environmental effects as challenging factors and inspiring forces in natural-built environments' design, as in 4D printing (Figure 4.25).

Figure 4.25. XenoDerma, 2018 by Urban Morphogenesis Lab, UCL (Pasquero & Polletto, 2019)

Design inquiries for new Objectile-Subjectile relations in the order of Advanced Metaheuristics: Having noted up to this point, swarm intelligence has found a wide-ranging operability and variant techniques that could be achieved in real-life applications of design. With the journey of abstract thinking, metaheuristics provide means of creative iterations on problem solving and decision making in artificial logic of intelligence (Sun, Lai, & Wu, 2012, pp. 23-24) like swarm intelligence. The field of architecture is not an exception in terms of being influenced by this logic. Further usage of metaheuristics algorithms in creating orderliness of an artificial life of swarm intelligence has many modifications by unfolding compounded constructers of statements into a sequence of hybridized algorithms using particle swarm optimization (PSO). '***Particle Swarm Optimization***' (PSO) (Sun, Lai, & Wu, 2012) is one of the most effective solution-oriented algorithms used in single-step solutions. Discrete PSO algorithms include vectorial kernels and more complicated functions (Sun, Lai, & Wu, 2012, pp. 75-142); and Hybrid PSO algorithms enable the embedded feature selection of genetic algorithms with other defined logical operators such as mutation operators (Sun, Lai, & Wu, 2012; Sun & Xu, 2017). These algorithms are efficient in the immediate facial emotion recognition of people (Mistry, Zhang, Neoh, Lim, & Fielding, 2017), and are used for material or behavior searches (Bing Xue, 2013).

The necessities of globally convergent feature selection algorithms further point out ***Quantum-behaved Particle Swarm Algorithms*** (QPSO) with fewer parameters, faster convergence rates, and more vital search ability for complex problems and probabilities (Sun, Lai, & Wu, 2012). Antenna design, biomedicine, mathematical programming, communication networks, control engineering, clustering and classification, finance, fuzzy systems, graphics, image processing, remote sensing (Chen, Chen & Jiang, 2016; Xu et al., 2017), power systems, metaheuristics, and adaptive-creative system modeling (Sun; Lai; Wu, 2012) are among the fields that make use of QPSO algorithms. The training of radial basis neural networks, load forecasting, chaotic frequency modulation signals, as well as various multi-parameter optimization problems (Sun, Lai, & Wu, 2012), can also be developed by hybrid QPSO algorithms. The strong and weak interactions among the particles and waves and the reconstruction of information about nature with the various features of its smallest elements can also be formulated via related algorithms (Abbas & Salman, 2017). Thus, the usages of these algorithms can also be applied in architecture by crowdsourcing, IoT, and urban computing. With the characters of polymers and other filaments interacting with quantum fields as well as other environmental forces, the particular modulations of 4D printing agents in architectural production, for instance, can be parametrized further through QPSO or other Hybrid PSO algorithms.

The networks of artificial (nanorobotics or) self-assembly production systems (Appendix C) considering Subjectile and the crowdsourcing methods in uncertain environments generate the challenge of production, automation, and construction. This challenge has the similar complexity of constructing on the Moon or even on Mars from the silicate-abundant soil to fill the pressure-based membrane structures and 3D printed Habitation Units (Leach, 2014; Howe & Sherwood, 2009, Foster & Partners, 2017) (Figure 4.26) that can be iterated through QPSO algorithms. Since the parallel and multi-networked computational agents are also more efficient than quantum-based informational processing[121], the hybridized solution of the swarms (Altshuler; Pentland; et al., 2018) of quantum-based information processing in that sense seems among the further possibilities of state-of-the-art technologies of the future, even for architecture. The said facts of quantum-based information processing (Bhattacharyya; Maulik; Dutta, 2017) are consequential to discussing the problems of deterritorialization of localities and the states of territorialized feature-based modalities. These problems can be searched with the inquiry of spatiotemporal and agent-based action relations and interactions via human-artificial modalities. This potentiates for possible resolutions of disjunctive states that can only be seen as evolutionary on certain grounds of collectivities as a professionalization problem.

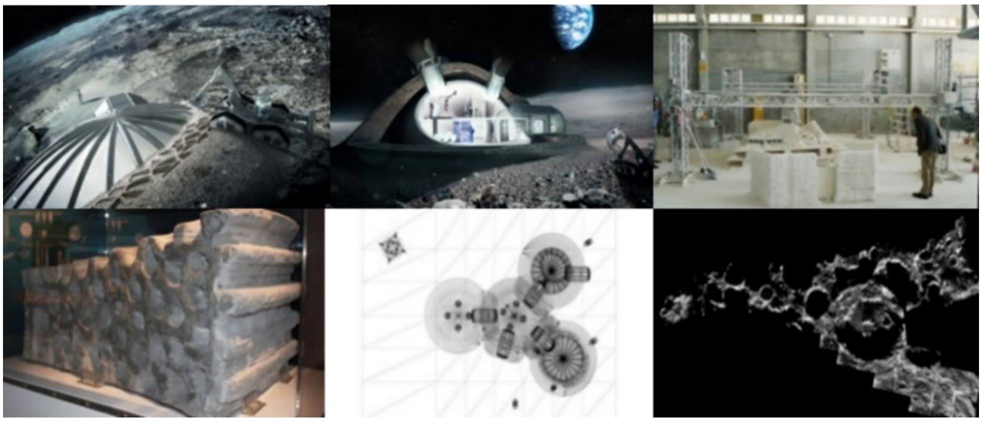


Figure 4.26. Foster + Partners' studies for constructing at Mars, Lunar Habitation Project, 2012 Mars Habitat Project, 2015, (Foster & Partners, 2017)

Modification of Multi-agent systems by the Hybridized QPSO Algorithms for self-assembly, nanomaterial technologies, and molecular computation: The keywords of signaling (Wen et al., 2018), remote sensing (Xu et al., 2017) via waves, and spectral decomposition for further research over the QPSO evoke the intelligent behavior of communication and an abstract language among each agent that can be defined with their features by genetic algorithms. This enables remote adaptation, production, and habitation systems decentralized from a territorialized formation of the architectural, organic, technological system as one of this section's major research inquiries.

[121] IBM-Q, Experience Documentation, User Guide, Internet: https://quantumexperience.ng.bluemix.net/qx/tutorial?sectionId=full-user-guide&page=introduction; See also Jean-Baptiste Waldner, *Nanocomputers and Swarm Intelligence,* ISTE/John Wiley: Hoboken, NJ, 2008.

It should not be forgotten that swarm intelligence's rudimentary modeling as an expectation of an intelligent outcome is somehow different from the agent-defined performative, emotion-search, collective agents of this study. This research follows to create intelligent and adaptable solutions, including particularities with their features, performative aspects, intuitive and hereditary kernels for swarm intelligence. Hybrid algorithms and operations enable further implementation of each sub-system not only among themselves as an intelligent being of feature-based performative and emotional action of agents on the one hand, but also a collective judgment system, on the other, for higher-degree intelligent generations/populations.

Besides the parameters of user comfort, behavioral, and cognitive aspects, the ultimate aim of production by the self-assembly systems in the development of nanofabrication, self-assembling robots, and nano-manufacturing are among other optimization inquiries (Appendix C). The habitation in decentralized uncertainty and the dynamics of evolution would be generated on the same principles of common logic between the natural and artificial (Howe & Sherwood, 2009) (Figure 4.27).

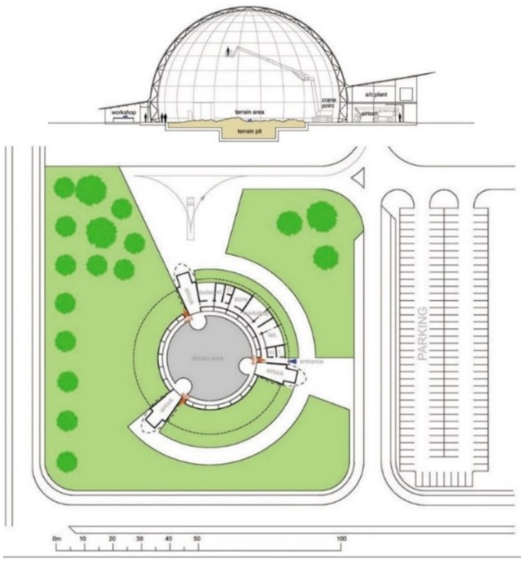


Figure 4.27. Project for a 'Simulator of the excavation on extraterrestrial sites/surfaces' (Howe & Sherwood, 2009)

MIT Self-Assembly Lab also offered possibilities in the emergence of self-producing evolutionary structures and self-assembly systems on the grounds of 4D printing (Papadopoulou et al., 2017) (Figure 4.28) with the dynamics of swarm intelligence.

Figure 4.28. Robotic Construction (Retsin, 2019) (left); Self-Assembly Chair, 2014 (right) (Papadopoulou, et.al, 2017)

Automation in Collective Construction by Molecular Synthesis and Informational Syntax of Self-assembly with Swarm intelligence: One of the most significant applications of swarm intelligence and the derived logic of Particle Swarm Optimization is used in the experimental Landesgartenschau Exhibition Hall in Germany (Figure 4.29). The project is developed by agent-based modeling by geometric and fabrication constraints at the building element level (Groenewolt, Schwinn, Nguyen, & Menges, 2017). In the project, it is crucial to understand 'the form-based topology' derived from the algorithms that make a coherent whole according to the center of mass of each element with their geometrical intricacies. Additionally, the long-term considerations of the features of the elements or agents of construction are based on the emergence and duration of the materials by their strength, flexibility, and tectonic dynamics in between.

It is to find more effective single-step solutions in the organization of disciplines during the design and decision progress just to decrease the feedback loop but also the complicated construction process of each tectonic element to be configured around a certain self-organizing pattern. 'Agent-based design model' is getting used to formalize, for instance, the planning progress integrating many different professional agencies from the structural analysis, life analysis, and prefabrication planning (Groenewolt, Schwinn, Nguyen, & Menges, 2017, p. 157). The system considers the possible constraints that can be encountered during the construction.

Accordingly, there have been many variables considered to reduce the complexity and cost of the design in advance in sequential phases. This means to model a much more complex solution-based algorithm considering the automated updates within the progress as a self-reproducing and evolutionary logic that is sophisticated from the precedent discussion on the systematization of multi-agencies and external factors in design progress (Groenewolt, Schwinn, Nguyen, & Menges, 2017, pp. 159-160). This requires a protocol that interactively controls the designer agent's behavior (Liu; Habibnezhad; Jebelli, 2021), layered in the solutions, such as optimizing the geometric organization (Figure 4.29). Additionally, the system attempts to optimize the uncertainty among the construction elements, including structural, material, tectonic problems, through data integration that is external to the geometric design (Groenewolt, Schwinn, Nguyen, & Menges, 2017, pp. 155-186).

Figure 4.29. ICD/ITKE Pavilion - Landesgartenschau Exhibition Hall, Germany (Groenewolt, Schwinn, Nguyen, Menges, 2017)

The remote construction agents can also be classified through their missions in extraterrestrial environments, and the robotic agents can be similarly organized in sub-clusters (Howe & Sherwood, 2009; Parks, 2012). The efforts of Foster + Partners have revealed exemplar simulations for constructing on the Moon and Mars, as similar to the studies of AIAA (Howe & Sherwood, 2019) in the organization of artificial agencies in the ecologies of exploration and fabrication (Leach, 2014) (Figure 4.30).

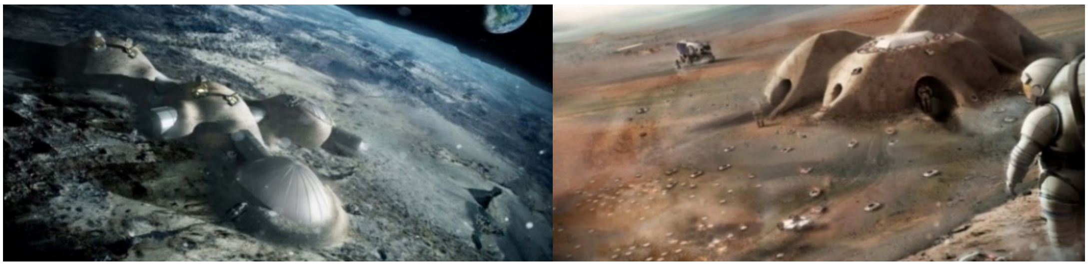


Figure 4.30. Lunar Habitation Project, 2012 (left) Mars Habitat Project, 2015, (right) (Leach, 2014; Foster & Partners, 2017)

Endeavors in the late first decade of the current millennium indicate the revolutionary systematization of automation in construction, justify the basis of the generic solutions for experimental explorations and iterations, and reveal the difficulties in real-time fabrication and construction. Chair model assembly of INT project conducted in the Bartlett School of Architecture, for instance, experimentally checks the adaptive stability of various elements of construction that are produced through self-replicating algorithms (Figure 4.31) (Tan, Tanskanen, Li, & Yin, 2017) in the order of swarm organization. At a larger scale, *PizzaBot* gives one of the most striking examples of how stable construction elements, inspired from simple pizza boxes, can be self-assembled with the help of moving fabrication and construction robots (Figure 4.31) (Claypool, Garcia, Retsin, & Soler, 2019, pp. 74-83).

Figure 4.31. Chair model assembly (Tan, Tanskanen, Li, & Yin, 2017) (Left); PizzaBot, 2018 (Claypool, Garcia, Retsin, & Soler, 2019) (Right)

The project has a creative reproduction method in self-assembly patterns exploiting the generative and inspiring evolutionary algorithms for configuration. Swarm algorithms are used in particular examples of robotic fabrication and automated construction. Similarly, Melenbrink and Werfel propose hypothetical construction processes in the challenging and uncertain conditions and geolocations as in the wide-spanning trusses over the valley (Melenbrink & Werfel, 2017; 2019) (Figure 4.32).

Figure 4.32. Hypothetical truss by automated robotic constructers (Melenbrink & Werfel, 2017)

As one of the pioneer projects, Philip Yuan's Chi-She Gallery (2016) has also revealed the automation in robotic construction with the moving arm of fabricators placing the ready masonry-wall components and doing the bricklaying task in place (Yuan, 2016). *Unit 19* by Ivo Tedbury similarly makes use of the swarm algorithms (Shi, 2015; Tedbury, 2017) in project organization and self-assembly progress of construction by artificial fabrication agents (Figure 4.33) (Claypool, Garcia, Retsin, & Soler, 2019). The computational basis of the project constructs nature-based combinations of elements. It runs through the workflow of data connections that assign each element and construction agent with respect to the property of structural/constructional elements organized through informational values and construction methods. With its social considerations, the project proposes generative usage scenarios that are available to citizens via the services offered by governmental bodies as giving access to the robotic constructors to build their fully automated housing units (Claypool, Garcia, Retsin, & Soler, 2019, p. 81) (Figure 4.33).

Figure 4.33. Unit 19 by Ivo Tedbury (Claypool, Garcia, Retsin, & Soler, 2019)

Accordingly, designating abstract; and yet collective principles behind development and growth strategies should always be a part of social, emotional, ethical, and logical considerations. This approach defines the aims of creative crowdsourcing, to come up with the intelligence of social and artificial collectives with creative purposes.

4.3.3. Transactions of Creative Crowdsourcing

Spatiotemporal actions of novel agencies of technology, deterritorialized in space with their interactions through user interfaces, and Subjectile should be seen as attempts to define collectivity among the agents and actions of swarm intelligence. This sub-chapter argues that a creative formation of collectivity in action cannot always be achieved in territorialization. The deterritorialization of locational features of the built environment or its agencies is another issue that can be discussed and can be seen as multidimensional topologies according to the paradoxes of territorialization. As a result, recognizing multiple collective conditions should be resolved in light of the evolution of information transfer between multi-agencies by crowdsourcing.

Spatiotemporal aspects envision the engagements of informational knowledge of space and the direct connection of the agents of new collectivities to the built environment. In this study, this will be analyzed under the emergence of urban informatics and Big Data, and subsequently questioned through the networked mode of creative crowdsourcing between the cross-relation of architectural agencies. Thus, the creative transformation of the organizational interaction of different collectivities is questioned under the societal or collective integration of multiplicities. On the one hand, this requires the reconstruction of collective relations through spatiotemporal practices in the built environment; on the other, it requires information transfer among the systems of multi-agencies to envision the cultural integration, connection, and communication of novel collectivities on the grounds of feature-based search of formal organizations through the fuzzy sets/systems.

The scope of this research, with the ‘generative’ and ‘holistic’ transactions in the systems of architectural creative crowdsourcing can hence be arrayed with regard to the wide-ranging topics of metaheuristics algorithms and AI applied through:

- Advanced solutions for production (in motion) via Objectile-Subjectile interfaces (with features/properties of emergences: objects/agents) within intelligent spaces
- Human-computer interaction, crowdsourcing, and data processing via Big Data and Internet of Things, and urban computing
- The research on potentials for new computational technologies focusing on architectural technology and its engineering
- Applied energy-related technologies and industrial/environmental solutions

The redefinition of ***the roles of collective conscience*** is urgent here to discuss distributing roles and agencies in crowdsourcing. In the inquiry of swarm intelligence, it is the lack of search on modular/individual abilities of intelligence, especially via emotion-related modalities. This mode of intelligence should be seen as the necessary epoch for human agencies. Additionally, the judicial role of collectivities (of Subjectile and Objectile) should also be included in the decision-making mechanisms. Collective Conscience or References can be seen as necessary for the re-evaluation of emotional and performative aspects in the inquiry of collective of different agent systems and formal intellectuality as intelligence even when regarding the correlation/interaction between human-computer interactions (Appendix C).

The attributes of subjectivity can be accessed via decision-making models and fuzzy sets (Zimmermann, 2010; Ebrahimigharehbaghi et al., 2021) in evaluating ***performative and evolutionary intelligence***, as they also arrange the degree of membership in recognition of elements (Appendix C). Moreover, the efficiencies of the neuro-fuzzy systems and genetic algorithms are tested in a study, for instance, on different examples of agricultural plants as the RGB colors that are converted into informational inputs (Neto, Meyer, Jones, & Surkan, 2003) to mimic human recognition (Appendix C). Thus, the question to ask, then, is 'How *the project of self-awareness and the project of recognition and design for a scientific built environment* as an organization of architectural agency can integrate the localized information of feature-based parameters of the environment?'. This question is consequential to be grasped first by analyzing the fuzzy sets and population evolution of feature-based data and time-related spatiotemporal actions and motions in evolution (Appendix C).

Roche's project, '*An architecture des humeurs*', develops an informational model for human understanding that includes artificial agencies' role and the creative synthesis of natural, subjective, and artificial data to substantialize how such topological data can represent and define the order of facts (Figure 4.34). This research can be used for different means of assessment, and represents simulations in molecular computation, crowdsourcing Big Data, topological data of smart grids, or intelligent spaces.

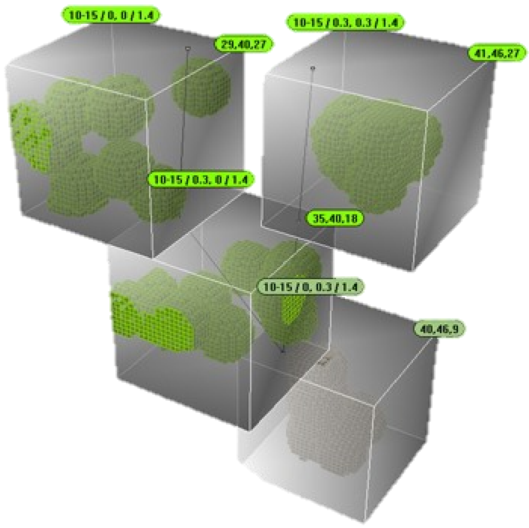


Figure 4.34. '*An Architecture des humeurs'* by Roche (Roche, 2013; Eiroa & Sprecher, 2013)

Thus, generative computations by inspired algorithms from bioinformatics and swarm intelligence can also be used for processing and analyzing such topological or ecological data. They may also be applied through the parameter-based topological information on human-computer interaction/correlation, the self-generating pattern of natural beings, crowdsourced data from automated many-body systems, or smart grids in complex configurational interactions (Appendix C). Such complicated transactions and computations can be concretized for each real-time scenario as in swarm production even with non-linear motion forces and directionalities with ever-changing angular momentum or infinitesimal rotations (Oxman, Duro-Royo, Keating, Peters & Tsai, 2014) (Figure 4.35). Applied physical force fields or technologies on elements/filaments can be similarly computed with the parameters and properties of production. It gives clues about higher-dimensional complexities in 3D printing or depicting the higher dimensional arrays for different ways of organizing 4D printing (Oxman, Duro-Royo, Keating, Peters & Tsai, 2014; Correa Zuluaga, Poppinga, Mylo, Westermeier, Bruchmann, Menges, Speck, 2020) (Figure 4.35).

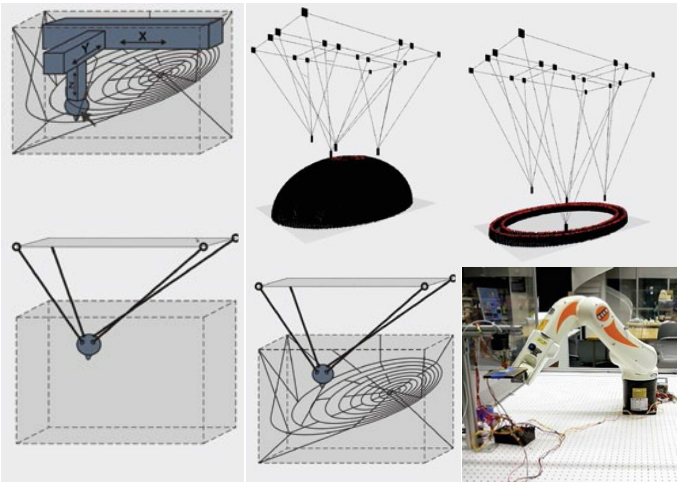


Figure 4.35. Oxman's research in real-time 3D printing experiment in the lab (Oxman, Duro-Royo, Keating, Peters & Tsai, 2014)

The mentioned computations can further be sophisticated by dynamic evolutionary algorithms changing property-based facilitation in each time-step to model spiking neuron topologies, as in neuromorphic computing chips (Davies, 2018, p.88). Similar topological data can also be acquired by Urban Computing (Zheng, Y., Carpa, L., Wolfson, O., Yang, H., 2014; Zheng, 2018). Such holistic models can also generate energy-related optimization of performance-related inquiries and prediction of occupancy behavior throughout various variances and modifications of algorithms.
Swarming the sensorial robotic/molecular construction agencies in creative formations

(Figure 4.36) (Yablonina & Menges, 2019) implies further possibilities of 4D printing by the various materials and filaments. This idea would give the safe and comfortable construction and tectonic possibilities embedding informational/communicational potentials that resonate and radiate at a particular scale.

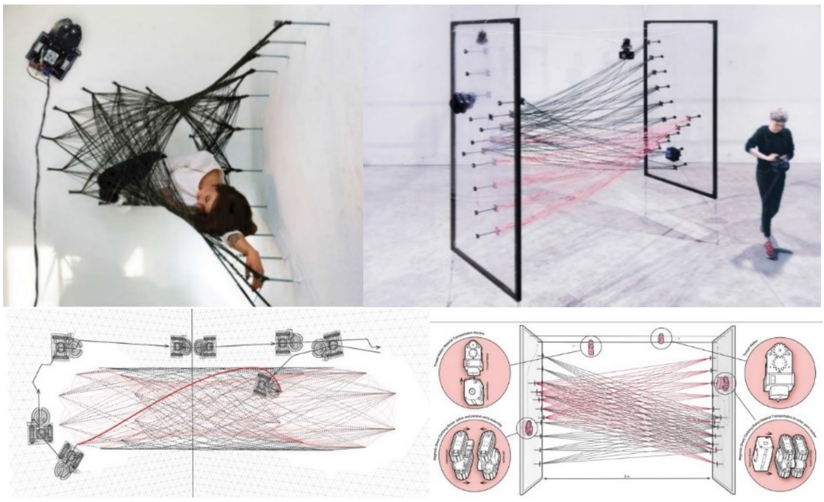


Figure 4.36. "MoRFES_02" (Yablonina, 2017)

The future of moving architectonic elements (Figure 4.37) with embedded computational technologies like “mutant Kilobots of PizzaBots” can also generate topological smart data crowdsourced from these agents. The complexities of creative crowdsourcing/crowdsensing, AR and VR technologies, the Internet of Things, and other human-artificial interactions/correlations through connected devices can add up to the generation and processing of such Big Data.

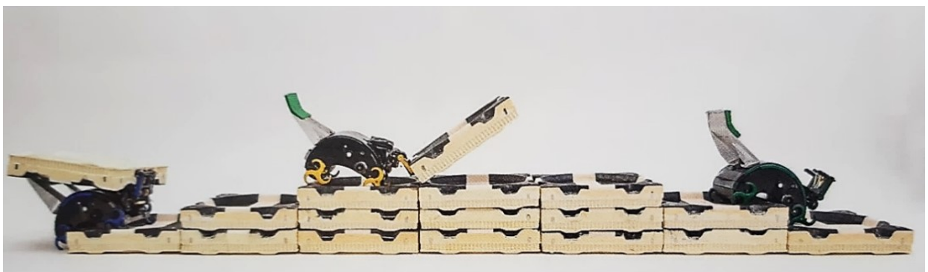


Figure 4.37. TERMES robots (Melenbrink & Werfel, 2017; 2019)

The inquiry on the generic computations implicates the creative crowdsourcing on smart grids, human-computer correlation/interaction, and even parameters for Objectile & Subjectile modalities. Creative crowdsourcing can gather the observation and crowdsourced data and feature-based object and action recognition together. Thus, the integration of fuzzy sets and logic can be represented as an increasing dimensional aspect of this parametrization (Appendix C).

Urban informatics/computing and Architecture: The distributive models of feature-based evaluation of collective forms in *Creative Crowdsourcing* pursue the challenge of 'Intelligence' of collective models on Objectile-Subjectile relation in intelligent spaces. This aims to reallocate the features of social and environmental aspects by the agency of architecture following the rules of society and context. Furthermore, it brings a new perspective to swarm intelligence on the problems of deterritorialization.

The previously mentioned idea for the scaled-up necessity of Arida's search over the Quantum City, in Oosterhuis's surveys, implies the generation of certain patterns of fuzzy communication sets to find connections among the society and the new mode of collective intelligence (Hight & Perry, 2006a; 2006b; Malone & Bernstein, 2015; Szoniecky, 2017). It is the integration of the crowdsourced data of demands, actions, and preferences of individuals, and the economic, social, political, and demographic features as well as the high-cultural values in defining the new Subjectile. This can be acquired through the Internet of Things and Big Data of recent crowdsourcing methods. Nevertheless, they need flexible numerical methods to be applied in the complexities of advanced manufacturing, construction, and in the immediacy of decision making. Beyond the agent-related data, the desired ways of spatial production, highly shared visual and architectural tendencies, and their critiques are the generative inputs for further inquiries of architectural findings, integrating the conceptual ideas and statements. 'Analysis of topological data' and the 'form' in the spatiotemporal action of preproposed models get complicated in higher dimensional topological data that are multiplied/polarized with time-derived and feature-based inferences to be organized around certain goals (Appendix C).

Urban crowdsourcing, the Internet of Things, and the new paradigms of urban informatics can also be represented by possibilities and challenges that are to be integrated with the architectonics and design procedures in intelligent environments

(Offenhuber & Ratti, 2014; Liberg, 2018; Tsiatsis, Karnouskos, Höller, Boyle, Mulligan, 2019; Eicker, Weiler, Schumacher, & Braun, 2020). Departing from the actor-network theory of Latour (Latour, 2005), 'Agent-based networks' and human-computer bases of information assessing swarming agents (Batty, 2011; 2012; Heppenstall, Crooks, See, Batty, 2012) would indicate the ground basis and method to transform data resources for the swarming behaviors. Hence, they can also be considered for property-based modalities (durations), as well as action in a specific directionality in motion under environmental forces, to be analyzed by urban computing (Zheng, 2018).

Organizational systems: The decision-making models, such as mixed logit models, should further be described, considering the aspects of individual choice, comfort levels, and energy-efficient precautions (Ebrahimigharehbaghi et al., 2021). The emergence of the localization rules of society and urban-built environment for the reallocation of the distributive systems occupy one side of this seminal concern. The evolution of the built environment into the determined forms of socio-cultural intelligence as in the decision of energy-efficient retrofitting (Ebrahimigharehbaghi et al., 2021) within the spatiotemporal practices is the other side of the same forms of intelligence that should be taken into consideration. Moreover, smart grids at the domestic scale can be simulated via networked agencies (Fettermann et al., 2019), such as swarms of WiFi shields or smart (micro)grids. This aspect is also essential to integrate multi-agency systems with societal and other kinds of reference systems by utilizing the conceptual principles of distributive systems and technology transfers. The creative togetherness of multi-agency systems with different performativity criteria can be evaluated together on the fringes of each possibility of action and feature-based relation by artificial intelligence models (Appendix C).

Then, it is possible to regard the generation of new decision-making models from the cross-correlation of different reference systems of action. Finally, the ultimate aim for the reterritorialization of the transformed knowledge should be decided at the last step again under the provision of Collective References and intelligence, which can be controlled by utility functions (Fettermann et al., 2020). Since most of the important missing features among such approaches arise from the lack of emotional contribution, the motivating goals, as desire beyond the networked actors within the superposed actions and reactions, ought to be explored by decision-making models. As an argument of the study, reterritorialization of agencies with the society and social rules of fuzzy sets can be distributed as territorialized data from urban informatics. Three-dimensional and more multidimensional models (Liang, 2016) to be integrated with the (universal) circuits can also become an inquiry of the architectural agency in spatiotemporal production of intelligent environments.

The advanced and hybridized distributive multi-agency systems ought to deal with complex and chaotic time-series that can be continuous on the one hand, to be studied by sequential neural networks, LSTM models, and discrete on the other, to be studied by convolutional neural networks. Similar models can also be used to integrate the moving agent's spatial experience and actions with the evolving set of relations that are pooled as memories to evaluate the networking of *creative crowdsourcing* for architecture and urban computing. Accordingly, the discovery of urban space and architectural possibilities requires a thorough exploration of each endeavor to deal with the questioned target, with a more significant problem of common sense in decision making (Ebrahimigharehbaghi et al., 2021) (Appendix C).

4.3.4. Concluding Remarks

The ideas of Henri Bergson from *Creative Evolution*, in this chapter, enable us to explore and classify the phenomenology of the discrete things that give birth to the actual dynamics of Life in evolution (Bergson, 1998), having inspired contemporary architectural practices and theory. These studies also hold an essential place in understanding the rising impact of new technologies such as molecular and neuromorphic computation together with artificial intelligence, genetic and evolutionary algorithms, and the role of the evolutionary shift of digital media in architecture in exploring genuine morphological forms, accompanying concepts, functionalities, and collective operations. This evolutionary process is further conceptualized with the distinct research fields of bioinformatics and swarm intelligence that appear in architectural research. Just as a recap, the analytical research in this chapter also enables us to remap some of the complex relations drawn out in the third chapter together with some generic examples in modeling the creative evolution in architecture (Table 4.5).

The rise of productivity and spatiotemporalities by human-computer interactions has revealed the role of accompanying concepts for informational grounds, metaheuristics, and optimization problems by bioinspired and evolutionary algorithms in the generation of topological Big Data. Urban computing, aside from IoT and the advanced inquiries on applied energy-related industrial solutions and technologies, as well as the Digital Twins of human-computer interfaces, imply larger-scale smart infrastructures. In that regard, this section can be seen as an initial step to the challenging 'many-body systems' with their ubiquitous data to be crowdsourced, measured, and parametrized for their environmental and spatiotemporal repercussions to the city and architectural spaces. The challenging uncertainties of many-body systems also question the theme of duration and motion studies with their repercussions to science, technology, and design. In that regard, this sub-chapter is supposed to serve the overarching concepts and modalities of the singularities and dynamics between the creative subject and architectural technology.

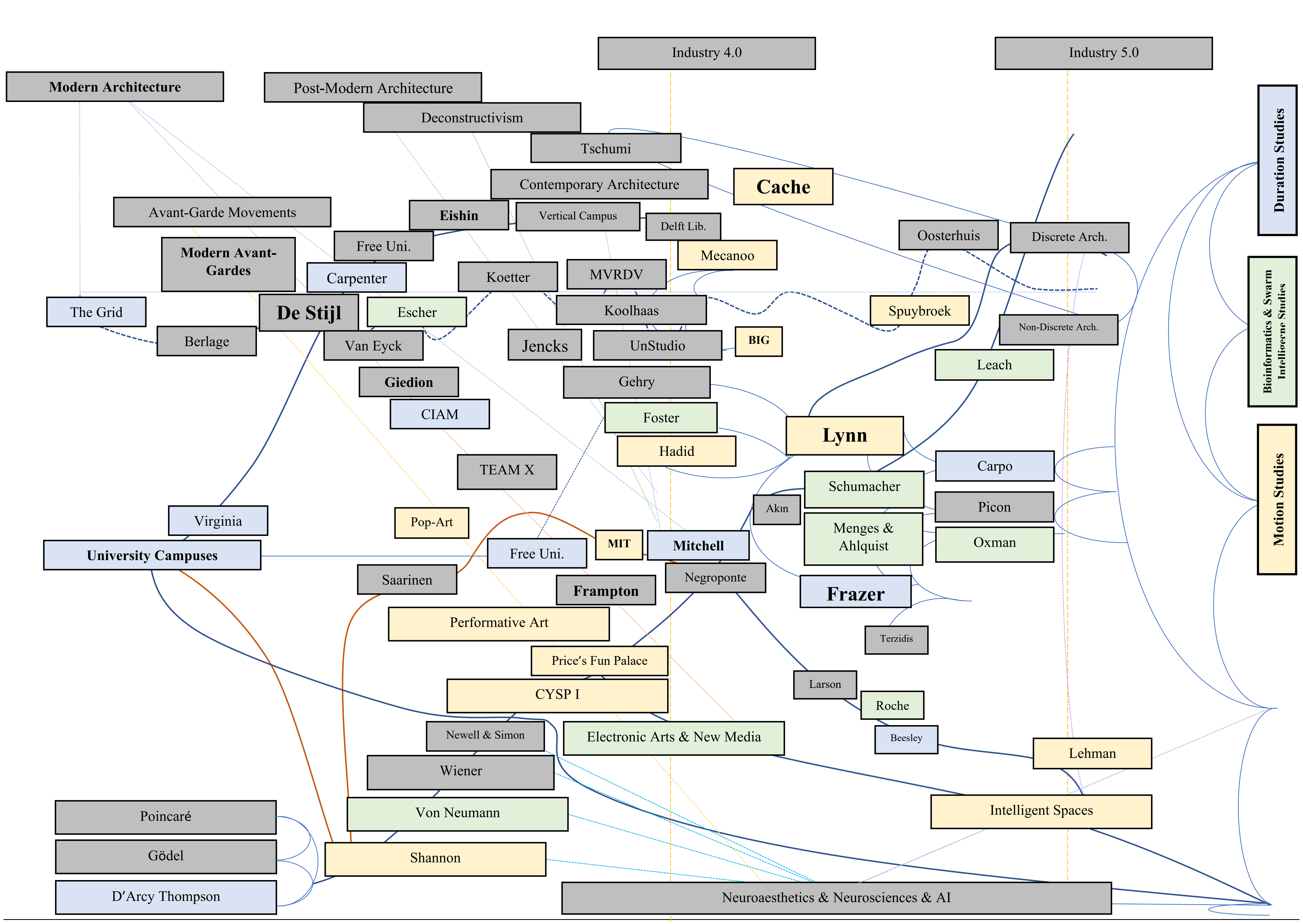
The proposed modalities here challenge the emerging paradigms of artificial and natural creativity by the theme of 'creative evolution' in architecture. According to Bergson, 'Creative evolution' is not only discrete but also continuous with regard to space-time (Bergson, 1998). Respectively, it is even possible to modulate the synchronous and asynchronous modalities of 'Discrete' and 'Continuous' agencies of constructions, forms, emergences, interactions, and even communications of the 'Multi-agencies' in the precedent analyses. The research regards the challenging togetherness of creative discreteness of modalities in their performativity, collective organizations as well as in construction, and in their physical form with two very different argumentations (Hensel, 2013; Retsin, 2019; Leach; 2019; Carpo, 2019) as a complex topology of intelligence. Hence, this topology should be regarded in terms of the complexity of the human-artificial-natural concept regarding the common grounds of creative architects-subjects, architectural technology, and the environment for unified collectivities.

The growth of science and technology potentiates a systematic design of togetherness of nature and the artificial that belong to a universal truth under the shadow of surprising particularities and possibilities that should be considered in equilibrium(s). Yet, it is not as pure and subtle as we can make predictions about science and technology. The precedent and even closer period of modernity have had two world wars and many 'instant' wars in the information age (Castells, 1997). This makes the designers of politics and decision-makers again responsible for the right decision, as the 'decision of the Master' (Lacan, 1998a; 1998b; 1998c; 1998d; 1998e; 2006a; 2006b; 2011b). Psychological and ethical dimensions of decision making are also extremely crucial in every social or scientific cluster.

Hence, the concern explored in this research does not describe a milder version of an instrumentalization of an authoritarian regime of new Machiavellianism as Hitler or Mussolini did before in social or political revolutions. As can be inferred, the common logic between the natural and artificial under the shadow of information is fundamentally open to be used as war machines, which are radically possible more than ever. Consequently, the technique and further application of QPSO algorithms indicate a paradoxical situation, and it is left again to the masterful selection of the ultimate decision maker, the subject, over the design of his/her future together with environmental or even astral measures. Just to remind an early modern criticism over the means and ends (Horkheimer, 2004), the journey of abstract and creative principles should meet the delicate balance in nature without harming its phenomenological roots; yet, it can be a part of the 'possible' evolution of Life. This 'possibility' legitimizes the unified togetherness of the artificial with the authentic, creative, and natural.

This challenging process, or possibility, however, faces the measurement of uncertainties. It reveals the singularities to be further analyzed via particular models and modalities to recover the novel cognitive, organizational, spatiotemporal, and epistemological grounds in the togetherness of dynamics of the creative subject, architectural technology, and environmental challenges. Further endeavor dwelling on this challenge is supposed to generate new agendas of research, practice, theory, and education (Şenyapılı, Basa, 2006) for the architecture of creative evolution. This endeavor should be checked with the challenging criteria in designing the built environment's future once the critical thresholds for the creative subject of architecture would be surpassed.

Table 4.5. Classifying some References and Examples in Mapping the Creative Evolution in Architecture



CHAPTER 5

ANALYSES OF INTELLIGENT SPACES AND SMART CAMPUSES WITH NEW SUBJECTILE-OBJECTILE RELATIONS

5.1. Introduction

Analyzing the evolution of architecture and the built environment by claiming on the abstract models and theoretical framework regarding the new capital investment on spatiotemporalities of technology and production, this chapter aims to study the alternative ways of transforming the built environment. Smart campuses, technoparks, research centers, and laboratories are seen as generative to reinforce the experimental studies on intelligent spaces, systems, and architectural technologies via the role of collective knowledge together with new peer-to-peer Subjectile-Objectile relations.

In the digital paradigm of architecture, Bernard Cache's seminal concept of Objectile becomes widespread and discussed with the advancing circumstances of Industry 4.0. Nevertheless, the emphasis on the role of the subject and Subjectile is either not discussed in an overarching manner, or remains opaque in the coeval period. Building upon this argument, the role of collective being and form of intelligence that could be developed by the role of institutional, social, and cultural aspects have also had little impact on production relations and their reflections on the built environment.

This problem can also be followed through the existing literature in architecture, as discussed in the third chapter. While discussing the potentials and relief that the digital paradigm has brought to the production and manufacturing in architecture, there cannot be found any significant work to emphasize the role of knowledge and its generation by the institutional endeavor. The new paradigm has solely enjoyed the discourse on the uncertainty of norms besides transforming the production and design relations for a certain period. However, the agenda behind the digital paradigm was also strongly related to the non-linear geometry and informational technologies as well as complexity theories. The significant studies in research universities around the world have also reinforced these findings, as in the rise of studies at MIT MediaLab.

In that regard, it could be claimed that interdisciplinary research in universities and their spatiotemporalities, like research centers or technopoles, could contribute to the development and evolution of further progress and new human-technology interactions. Technopoles and research institutes still generate the major endeavor on the self-assembly systems, Digital Twins, even 4D printing, new generation technologies, as well as the rise of cognitive sciences and artificial intelligence, and their togetherness with different research fields. New research centers and laboratories as intelligent spaces in the most respected research universities like MIT, Harvard, or TU Delft have already been proposed the development of smart campuses and smart built environments that can house new Subjectile-Objectile relations.

On the other hand, even though the investors of technology have dominated the flow of produced objects and their capital, as we attempted to discuss in the fourth chapter, they seem to abstain from investing in intelligent spaces, and yet they have newly started to produce smart home systems. Thus, only the upcoming period will reveal whether they would decide on further investment and development for intelligent spaces. This is one critical point that can also be familiar to the problem of lack of discourse on universities in the digital paradigm of architecture. Thus, this research decides to develop further arguments on these two distinct findings on intelligent spaces and university campuses. This chapter further claims that the togetherness of the rise of intelligent spaces with the roles of university areas towards the new and creative relations of Industry 5.0 can generate new paradigm shifts. The integration of research on cognitive sciences and smart spaces can generate new spatiotemporalities and informational knowledge. This should be investigated through the paradigmatic relations of informatics, sites of high technologies, institutional relationships, and cognitive and spatiotemporal aspects of intelligent spaces.

This investigation also sheds light on the aims of the thesis clarifying the possible audience and benefiters of the study. It is believed that the research can gain the attention of policymakers and decision makers, such as the administrations and executive directors of research universities and users in university environments.

Designers, researchers, and scientists that need to develop intelligent environments can also benefit from the analyses of this research. Additionally, the research has the potentials to indicate new teaching experimentations in the academic environments[122] via intelligent spaces that would be novel for both academicians and students, as a necessity in the rise of online learning, as mentioned in the third chapter.

Larger scale territorialization in economy politics of high technology giants and rising research on learning environments: The rise of informational technologies offers niches of spatiotemporality by contextualizing the flow of Big Data of people's preferences and tendencies that are tried to be defined as the new Subjectile, departing from Bernard Cache's seminal concept (Cache, 1995). Moreover, intelligent learning spaces can provide potentials of social interaction and knowledge transfers besides the new interfaces for subject-technology relations through Big Data and the Internet of Things that we attempt to identify by new Subjectile and Objectile relations.

Novel technologies and innovative attempts, such as the usage of smart grids/infrastructure and smart automation networks for intelligent environments, are also on the recent agenda of technology companies. Research on smart automation systems and networks has also gained importance and become the prominent domain for knowledge generation with the increase in research capacities that most institutions, research groups, and academic researchers intensely focus on. There is also the ascending possibility that the recent developments for the connected devices of smart home applications of large companies like Apple HomeKit, Google Smart Home, Microsoft IoT, Samsung SmartThings (Xiao et al., 2020), at the center of economic relations, could even soon dominate the business sector.

Nevertheless, only the passage of time will tell us once again whether technology giants will decide to invest further in these (on-site) technologies because it is barely possible to talk about the rise of the larger scale or comprehensive intelligent building developments beyond a few exceptional examples and investments. It can be claimed that high-technology giants do not usually prefer to directly develop non-profitable or costly progressed development of hardware/sensor-based projects, as only some of

[122] See also (Anderson, 1997).

them have recently started to invest in smart home systems. Nevertheless, the study tries to find possible correlation/synergy between Objectile-Subjectile and the environment as a form of intelligence. In that regard, it is even possible to claim that intelligent spaces for the transfer of knowledge and social interaction could be one aspect that could resolve the profit-oriented and yet crisis-prone strategies of capitalism (Harvey, 2014).

The development of intelligent environments with cognitive aspects and socio-environmental forces of the built environment is also believed to volatilize the shift from the planar relations between Objectile and Subjectile towards the reinforcement of subjective decisions and performance mechanisms. Moreover, regarding the condition of Subjectile and the recent rise of state-of-the-art technologies like neuromorphic computing chips together with intelligent environments (Arbib, 2012) can be envisioned as the pedigrees of architectural practice.

For the development of intelligent environments regarding the evolutionary dynamics of the mirror stage between Subjectile and Objectile (Cache, 1995), Maria Lorena Lehman's seminal study, *Adaptive Sensory Environments* (2017), can be introduced to envision this transformation. Thus, it becomes possible to have literature-based research on adaptive environments that can also be named intelligent learning spaces, and which acquire environmental and user data and respond accordingly (Lehman, 2017). Making predictions about the usage and environmental changes can be seen as the most promising features of such architectonic and architectural developments regarding the integration of smart systems with self-sufficient design and construction elements, not only at the production scale but also as adaptive to ubiquitous changes. Corresponding architectural paradigms with regard to the rise of the new computational technologies, accordingly, have generated the new endeavors of research and practice in architecture that investigate the cognitive and organizational grounds. This argument leads to new discussions on the challenges of the built environment, viewed together with the action of its agencies and the condition of the creative collectivities under the influence of the new paradigms in architecture.

Regarding Adaptive Sensory Environments as one of the significant milestones in the 'architectural literature', the rising role of artificial neural networks in the automation of smart systems and infrastructures gets more attention. Furthermore, the challenging rise of the Big Data of environmental inputs and aspects, respectively, ought to necessitate allocating such technologies together with the complex smart systems regarding the role of Subjectile and interfaces with Objectile at the scale of urban computing (Zheng, 2018) and social spaces.

The book *Urban Computing* also disseminates the methods and techniques for urban crowdsourcing that also include the descriptive survey on current models as well as novel applications regarding the technological capacities for human-centered and sensor-based data collection and processing (Zheng, 2018). Designing according to the informational data of environmental and sensorial inputs becomes increasingly critical, and the limits and potentials of technology also inevitably influence the spatial design of the surrounding built environment with spatial attractors and smart systems. Nevertheless, this can also be seen as an opportunity for architecture and design to decide on the necessities and critical attraction points that ensure the necessity of technological and innovative solutions. Maria Lorena Lehman claims to resolve this rise of complexity by generating 'control' points to deal with the challenging possibility of the rise of each cognitive and environmental dynamics to keep the 'identity' of the building and its design consistent (Lehman, 2017). In that regard, at the architectonic scale, the design of control points in the rising dynamics of kinematics and design informatics (Lehman, 2017) can be claimed as one genuine idea to regard the compact future of the creative collectivities of Subjectile-Objectile relations in intelligent built environments. Thus, the online Big Data of users and interactions of human and artificial agents of adaptive and learning environments can be controlled better by the investments in the relationship between spatiotemporal organizations and the state-of-the-art Objectile via the designed spatial attraction points.

For the larger scale, this critical concern needs further overarching parameters and knowledge to find consistent 'control' points and 'research aims' between the evolutionary dynamics of cognitive and spatiotemporal relations of collective togetherness and architectural technology. The roles of technoparks, research and development centers of universities or institutions with certain academic targets become significant, then, in this scope regarding the studies of cognitive sciences and learning environments and the research bases, in developing new generation technologies and spaces. Respectively, this chapter turns its attention towards the role of smart spaces in larger-scale sites of high technology such as research campuses and techno-centers, producing information and knowledge bases.

How can technoparks and research universities be the solution spaces? The digital paradigm in architecture has enjoyed the discourse on the lack of agenda behind the transforming production and design relations for a long time. However, one of the major shifts in the twenty-first century's theoretical paradigm in social theory is concerned with the capacities of economic and professional practice as well as the organization of space emerge in the discourse on collective practices in academic environments and its spatialization practices in contemporary built environments (Erişen, 2020b), and the case in Turkey is not an exception. Information also plays a critical role in the global dissemination of this generative experience. Thus, this chapter has a question of whether this discourse has substantial grounds to have argumentations on knowledge generation of spatiotemporal practices of smart university environments other than the genuine phenomena in Silicon Valley.

On another line of thought, intelligent environments still need special testbeds that should generate the necessary dynamics in the integration of larger scale built environment dynamics with cognitive research and technologies. This gap can only be overcome by knowledge production and collective decision making, which is tried to be studied via abstract models and related examples in this thesis. The cases of learning environments and university campuses have already revealed the practice of modern scientific knowledge in the scrutiny of collectivity and production of spatiotemporalities with their profound social and cultural meanings (Sargın & Savaş, 2016). There are alternative milieus for academic environments and research centers in the university campuses to integrate the larger scale technologies, cognitive research, creative models, the production of information-intense knowledge, and its creative learning subjects through the pipeline of decision-making, for instance, via IoT projects for smart campuses (Valks et al., 2020).

The information-intense knowledge and production in universities with more focused research aims, regarding intelligent spaces together with new Objectile-Subjectile relations, in that respect, lead this research to evaluate the smart campuses and research centers. The rise of the information age with the increasing influence of technology transfer compels us to regard the developments of research university campuses in close connection with industry, start-up companies, and research-based institutional regions. Silicon Valley and Boston Route 128 have implied the most remarkable sites of university-company relationships (Castells & Hall, 1994). As research universities start to play critical roles with technology transfer models between institutional research and larger scale investments, Technoparks and smart environments in the dynamics of collective togetherness in production and social relations also remind us of the success stories of Silicon Valley (Castells & Hall, 1994). The role of research campuses and especially the Technoparks also need to be inspected in the scope of this critical inquiry regarding the new technologies of crowdsourcing and Big Data in the new definitions of collective forms of informational data and its knowledge. The generation of knowledge with the elaboration of intelligent and adaptive sensory environments in high technology sites or smart campuses and technopoles thus stand to be explored as novel endeavors.

Therefore, the cases from TU Delft, as well as some particular examples from MIT and Harvard University, are to be inspected to gain a broad view of the development of intelligent spaces, learning environments of scientific and academic research, and smart campuses in/for new Subjectile-Objectile relations. The research aims to evaluate the condition in Turkey, in particular the cases of Bilkent University and especially ODTÜ Teknokent, according to the mentioned discussions on intelligent environments and technology transfer within new Subjectile-Objectile relations.

5.2. From Urban Informatics to Computing Smart Campuses and Intelligent Spaces: The Cases at TU Delft, MIT, and Harvard University

Having implied the successful examples with utmost research impacts, the academic background and research tradition integrated with the new visions of TU Delft campus is one of the strongest candidates to pioneer the transformation of smart university campuses. The rise of intelligent spaces and their larger-scale integration with smart campuses in technical aspects will bring us the visions for new crowdsourcing means that require the closer inspection of the physical condition of spaces with wide-ranging and different technological possibilities. The survey and experimentations on the most suitable development models regarding spatial needs and technological possibilities will reveal the generic outline for how the design and decision making parameters for crowdsourcing and transformation of spaces with different means and techniques can be implemented to transform intelligent campus environments (Erişen, 2020a). The outcome of this research will then enable us to analyze which new means of crowdsourcing techniques are developed regarding state-of-the-art technologies, energy-efficient transformations, new numerical methods, and scientific research.

Artificial intelligence and new means of crowdsourcing have brought us the capacities and possibilities of the generation of informational knowledge by Big Data. The increasing influence of sensorial environments and data processing techniques by computational learning models provide the basis to determine whether it would be possible to transform campuses into smart and energy-efficient learning environments in all aspects. When evaluating the distinct cognitive and organizational aspects of the campuses together, the cases ought to be searched in the new inquiry of the development of research-related intelligent environments. In that regard, it is crucial to learn from the decision-making models integrating the successful examples of technology and production-related developments with the research-based environments of the university campuses towards smart campuses (Valks et al., 2020).

The role of IoT technologies and applications in crowdsourcing, supporting decision-making models, at the smart campus environment is recently studied on four university campuses in the Netherlands, including TU Delft (Valks et al., 2020). That study explores the roles of smart systems and the potentials of IoT technologies with an initial survey on different researches. The study then explores how IoT technologies can provide real-time data on space utilization by user occupancy and other environmental/sensorial inputs so that decision-making models based on IoT-based data are used or can be developed for planning smart campus environments by exploring facts from four different universities (Valks et al., 2020). The study also provides a groundwork for the discourse on smart campuses supporting experiences, preferences, and decisions of new Subjectile by exploring the capacities of campus environments.

Accordingly, this research supports the idea of intelligent learning spaces with socially responsible larger-scale spatiotemporal developments. Thus, universities can provide infrastructural capacities for cognitive, spatiotemporal, and organizational transformation of science and technology in close connection to production and society. The research believes that the extension of technology transfer via the rise of smart spaces in research laboratories of universities will provide further development of intelligent and learning environments for smart campuses with the larger-scale investments and developments for further action and growth in urban environments.

The research and development centers of universities also become apparent, especially in the studies of cognitive sciences and learning environments and the research bases in developing new technologies and spaces as in MIT MediaLab. In the integration of sustainable architecture and energy-efficient smart campus environments, the aim of developing smart spaces and smart campuses also depends on deriving decision-making methods and institutional principles on how possible growth models can be implemented through spatial needs and technological possibilities.

The research accordingly focuses on which research methods, means, models, and technologies or environments are selected according to these questions. Thus, the research aims to analyze new crowdsourcing techniques to be integrated with imaging devices and sensors to evaluate the physical potentials and constraints of architectural and campus environments and their crowdsourcing to retain information about the needs and limitations of learning environments, energy efficiencies, and management methods. Smart grids and photovoltaic systems, for instance, can also be among the interests of this inquiry, influencing new Subjectile-Objectile relations.

The originality of this chapter undoubtedly depends on analyzing related research with selected crowdsourcing techniques that should also be decided with the potential and limitations of the physical environment (Erişen, 2020a). The research puts forth that earlier studies and data research about the integration of learning environments into smart campuses (Foth, 2009; Valks et al., 2020) will further provide grounding data/information for new generation technologies. This finding orients the research to explore new means of crowdsourcing with secure and even energy-efficient online learning models for learning environments in the generation of Big Data. Accordingly, the study evaluates the physical crowdsourcing techniques through smart systems and IoT technologies. In the integration of technological and scientific inquiries, the interdisciplinary search opportunities in universities also become prominent. With the research from computer science, electric-electronic engineering, statistics, data analytics and management, and energy research, the initial endeavors provide further bases to be studied with new means of technologies and emerging research fields.

As Delft University's Q-Lab has already announced it publicly in 2017, it becomes possible, for instance, to communicate between the two distant locations of campus buildings by the laser sources by experimenting on the beam splitter located in one central building to measure whether the laser sources are entangled or not (Bertels et al., 2018; Almudever et al., 2019). Quantum entanglement experiment between TU Delft campuses was one of the most impactful research that make the Delft University campus a smart campus environment that can be integrated with other new-generation technologies (Figure 5.1) (Appendix D). The usage of light sources, environmental interactions, and complexities, as well as new numerical methods besides the usage of holograms (Richardson, 2018; Anadol, 2020), optical computation, or the usage of hybrid technologies, are quantum technologies and techniques that ought to be integrated with the built environment (Figure 5.1) aside from natural computing for the possible solutions of universal circuits. Thus, the research claims that futuristic technological capacities make the creative collectivities of architecture think and act together. The simulative models or new means of crowdsourcing have also become much more efficient in the rise of quantum computation. This experiment in quantum communication by laser sources (Figure 5.1) has also revealed realizations of Mitchell's utopia about novel infrastructural transformations (Mitchell, 2003b).

These complicated technological and scientific considerations require specific considerations in the design of the built environments. National Ignition Facility is another significant example, which was seminally presented by Charles Bennett in

2008 as the largest optical quantum computation laboratory based on the ignition of laser sources (Figure 5.2). The fact necessities the discovery of the potentials and even the envisioned growth of the 'System Phase' of Quantum Computers as sufficiently sophisticated to be commercialized to solve real-time problems (Figure 5.2).

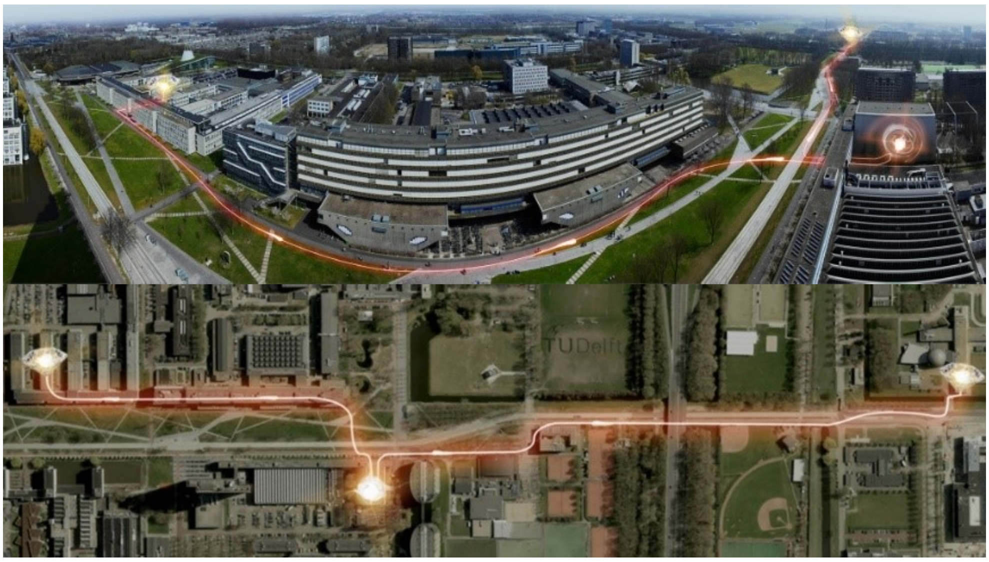


Figure 5.1. Quantum entanglement experiment by laser sources and beam splitter in/between TU Delft campuses (Images accessed on 16.05.2020 from https://qutech.nl/hanson-lab/research-highlights/hanson-lab-loophole-free-bell-test/)

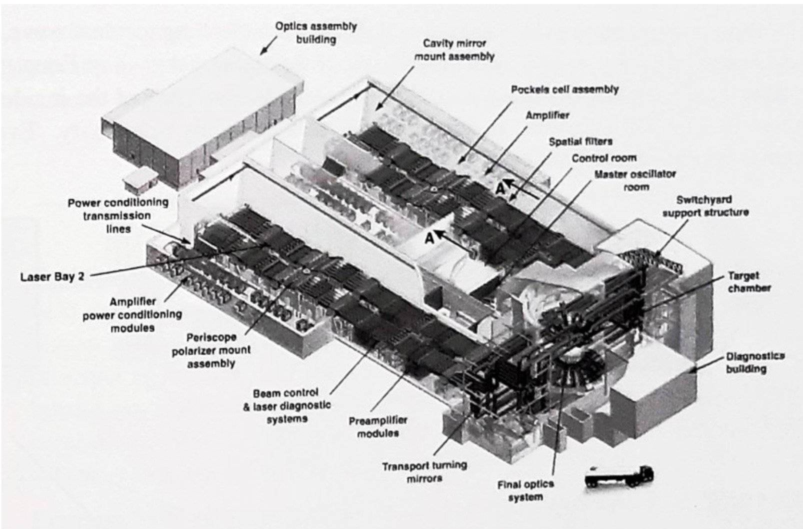


Figure 5.2. National Ignition Facility and its design (Bennett, 2008)

New computational complexities regarding (swarming) collective intelligence under the challenges of the uncertainty of action and states (of things and energies) also imply the timeline of the planned future of these new technologies, as in the ones of quantum computation (Figure 5.3).

Figure 5.3. The Tangle Lake 49-qubit quantum processor (Intel, 2019) (left); A Timeline of Quantum Computing (IBM, 2018, 2020) (right)

Quantum Information can encrypt the development of environments as the networked ecologies of energy efficiency with unique informational communication infrastructures to follow the natural resources as well as users' predilections, ideas, and long-term impressions through different synchronous or asynchronous bases (Appendix D). The special design of the built environments cannot only work to follow the possible bioelectrical, biomass energies, biovoltaic representations of information (Ok, Tsang, Bolan & Novak, 2019), and reactions of the natural surroundings, but also develop a new way of communication through optical photonic innovations (Figure 5.4), yet they may require quantum programming. Respectively, designing environments and architectonics for quantum computation other than idiosyncratic explorations in classically designed spaces/environments should be extended and mixed with other classical resources of information and communication.

Through the ongoing research, as achieved through the academic vision and the future expectations of the university in similar aspects, it also becomes possible to integrate IoT applications with Quantum technologies (Ding et al., 2020). The emerging research work on the state-of-art-technologies with energy concerns and on the technical details about how those systems operate and by which parameters the efficiencies and characteristics of the research outcomes are followed (Ding et al., 2020). New generation technologies with a greater impact on sustainable and energy-efficient environments through photovoltaic systems are also among the studies that are the generators of transforming environments, and TU Delft is one of the pioneers of such research (Jager et.al, 2014; Isabella & Vasudevan, 2020).

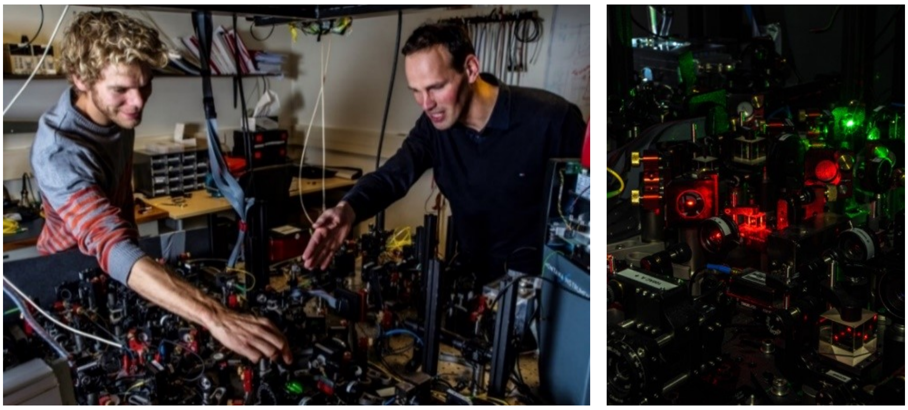


Figure 5.4. An example of an Optical Quantum Computer, QU Tech Lab (Images retrieved on 16.05.2020 from https://qutech.nl/hanson-lab/research-highlights/hanson-lab-loophole-free-bell-test/)

As another significant example of intelligent spaces in new Objectile-Subjectile relations, SenseLab in TUDelft, founded by Bluyssen and her team (Bluyssen et al., 2018), can be analyzed. Besides the development of the experimental laboratory as an intelligent space, Bluyssen's seminal research surveys the capacities of the built environment, design requirements, integrated systems, and experimental environments for collecting data about indoor spaces. Integration of other technological capacities based on IoT devices and online learning systems are planned to provide ubiquitous information. Energy models, in that regard, are also supposed to be developed based on the generated data.

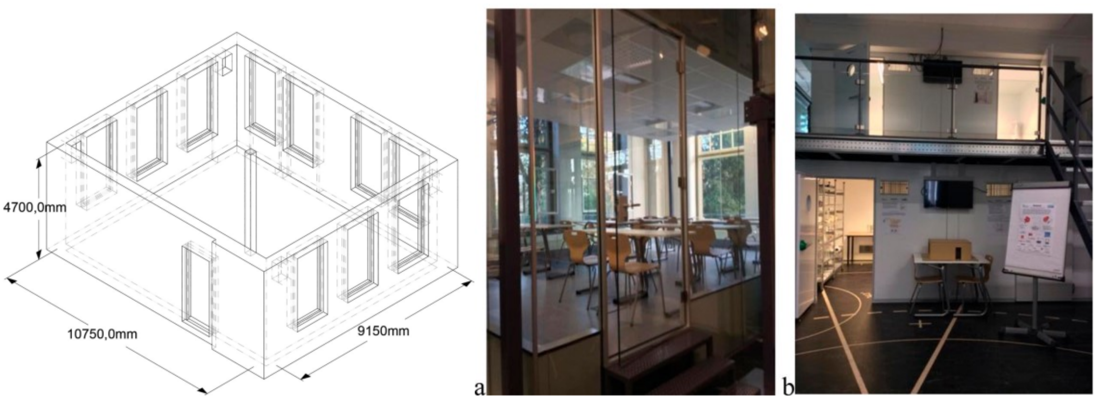


Figure 5.5. Science Centre in Delft, allocating space for SenseLab (left); (a) Experience room, (b) test chambers (right) (Bluyssen et al., 2018)

Thus, it is essential to regard the increasing number of research groups and intelligent environments under the vision of being a smart campus, as TU Delft has recently founded 24 AI labs studying in various fields of research (TU Delft AI Labs, 2021). Two of those significant research groups, 3DUU and AiDAPT, work on architectural environments. 3DUU studies remote sensing in grasping the human environment at a larger scale in 3D (3DUU, 2021). The recent AI technologies and crowdsourcing methods, including CNN and LSTM neural networks, are applied at 3DUU to efficiently model the built environment regarding environmental challenges, human-technology interactions, and other concerns involving architects, urban planners, and researchers in cognitive and computational sciences (3DUU, 2021). AiDAPT (AI for Design, Analysis, and Optimization in Architecture & the Built Environment), on the other hand, applies state-of-the-art machine learning and deep learning techniques for a sustainable built environment in analyzing lifecycle patterns and Big Data from the built environment (AiDAPT, 2021).

The exploration of the physical and campus-based parameters with limitations and possibilities reveals the initial experimentations on how the groundworks for decision-making models and learning models would be developed. In that regard, in the development of intelligent environments for smart campuses, the critical concerns about energy-efficiency and new means of computation technologies need to be evaluated with studied decision-making pipelines and IoT technologies (Valks et al., 2020). Moreover, the technique of crowdsourcing of people’s actions, special needs of the environment, and the generation of Big Data of learning environments have the strategic importance that should be evaluated with the question of how commonly used learning models can provide mathematical methods and learning techniques for new generation technologies on a larger scale. The physical configuration of intelligent systems can affect the design of environments and learning aspects in user occupancy and energy-related parameters (Guerra-Santin & Itard, 2010; Ioannou & Itard, 2015) for indoor environments that are to be learned by deep learning models acquired through IoT devices. Thus, integration of deep learning and machine learning models with IoT applications (Erişen, 2020a) is a significant step to recognize human-environment and human-technology interactions in founding intelligent spaces.

Previous studies on urban informatics have similarly revealed the role of campus environments of research universities as in the cases of MIT and Harvard University (Foth, 2009). Many types of research were conducted, especially at the MIT campus, as a series of crowdsourcing studies on Internet usages of users towards transforming the campus with intelligent environments (Foth, 2009).

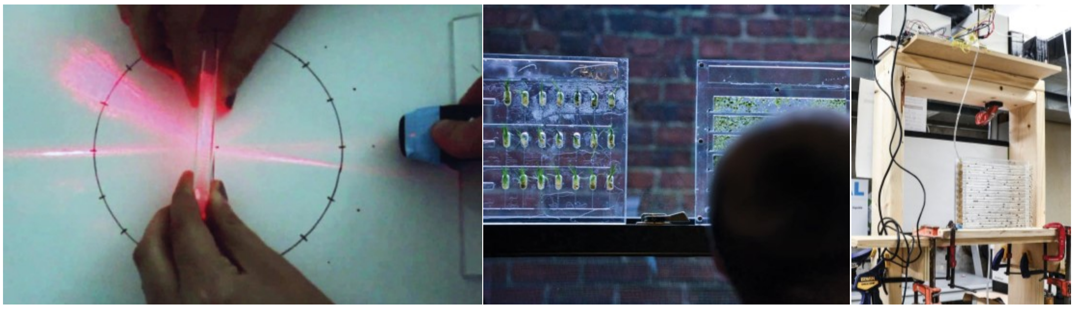
Founded by Negroponte in 1985 and expanded according to the ideals of Mitchell on cognitive sciences and technologies, smart cities, and campuses (Mitchell, 2003b), MIT MediaLab accordingly has a distinguished place in the interdisciplinary research at MIT. At this point, it is also crucial to describe once again the deliberate design of Fumihiko Maki at Media Laboratory (Figure 5.6) (Mitchell, 2007). The experimental spaces and collective groups are arranged around various experimental labs and influential research groups from Affective Computing (Picard, 2000) to biomechatronic, city science, and especially the responsive environments group, which is led by Joseph Paradiso (MIT MediaLab, 2021).

Figure 5.6. MIT Media Lab, designed by Fumihiko Maki

Recalling the earlier studies on intelligent environments in *House_n Research Consortium*'s, *Urban–infill condominium*, and *The PlaceLab* (Larson, 2010), Paradiso's group of responsive environments has made further inquiries into the development of sensor networks and the assessment of human-nature-technology interactions in contextual (natural) environments (MIT Responsive Environments, 2021). Applying various investigated abstract models, data crowdsourcing, and processing methods, the research groups at MIT MediaLab can thus be introduced as one of the pioneers in expanding new Subjectile-Objectile relations with innovations in the environment.

Similar impactful research has also been achieved in MIT SelfAssembly Lab, in MIT's International Design Center, studying 4D printing pioneered by Skylar Tibbits (Tibbits, 2014; 2017). In applying self-assembly methods and computational capabilities, the scope of the experimental laboratory emphasizes one of the exceptional examples for investigating new Subjectile-Objectile relations under the conduct of special research environments (MIT Self-Assembly Lab, 2021).

There are also some inspirational foundations at Harvard University that are closely related to new Subjectile-Objectile relations in architecture. Investigating the property-based topological formations with architectural and natural entities, on the one hand, and the swarm behavior of different artificial agents, on the other hand, Martin Bechthold's experimental studies with his team (Figure 5.7) have been extended with the founding of the *Laboratory for Design Technologies*.



1 2 3

Figure 5.7. 1. PDMS Light shelves by Adaptive Living Environments (ALivE) group, PDMS-based deformable array of light shelves, Harvard University Graduate School of Design (GSD), Cambridge, Massachusetts, 2014; 2. Living Wall by Adaptive Living Environments (ALivE) group, 'Living Wall' prototype, Harvard University Graduate School of Design (GSD), Cambridge, Massachusetts, 2014; 3. The fluid display system, by Harvard University Graduate School of Design (GSD), Cambridge, Massachusetts, 2014 (Bechthold & Sayegh, 2015).

The laboratory investigates responsive technologies with sensing, adaptive, and smart material systems, robotics and additive manufacturing, computational design and modeling, and urban data analytics (Laboratory for Design Technologies, 2021). In these experimental works, the agents are not only observed as a part of construction itself but also within the existing tectonic and artificial dynamics. In the *Adaptive*

Living Environments project (2014), for instance, the isolation of the optical features or the isolation of environments by architectural and architectonic elements are designed as hybrid systems with optical features (Figure 5.7).

The research regarding the particular cases from MIT and Harvard University, besides many particular works in UCL Bartlett School of Architecture or in Stuttgart ICD (Institute for Computational Design) led by Achim Menges, as briefly discussed in the precedent chapters, have only revealed the primary examples of new Subjectile-Objectile relations. In that regard, it can be summarized that the rising collective research groups and investigation into experimentational spaces have still been developed primarily under the conduction of university administrations. These exemplar developments urge us to analyze the spatiotemporal, collective, and administrative cases in Turkey's particular contexts.

Investigating for Intelligent Spaces of Universities in Turkey: The local dynamics of the closer research centers and the legislative rules of the republic have enabled the development of sites of high technology, ODTÜ Teknokent, and Bilkent CYBERPARK in Ankara. These significant research sites are on the agenda that ought to be evaluated in the togetherness of intelligent environments and territorialization of research campuses. From an academic perspective, apparently, universities and the new technology campuses with the research-based companies reveal contradistinctive and yet dependent relations with each other.

Following the successful examples of Silicon Valley in the initial incubation centers established in 1992 by ODTÜ TEKMER, Teknokent's first building started to be constructed in 2000, though under the administrative organization of ODTÜ (Teknokent, 2021). The decision had been made to initially control the foundation through the specific state-regulated investment policy as a conduction model of the Republic (Teknokent, 2021). The legislative rule of "Technology Development Zones Law No. 4691" in 2001 had legitimized the technology development regions in Turkey; and has enabled tax-free entrepreneurship of R&D centers and start-up companies to be founded in ODTÜ Teknokent (Teknokent, 2021). Additional institutions and buildings further extend this spatial and organizational scope that houses the research on high technology and informational and cognitive studies that can be further reinforced with intelligent spaces. ODTÜ Teknokent genuinely describes the related impact of the site and the scope of organizational foundation corresponding with the facts, including the inhabiting labor force:

> "Being the first and the most innovative technopark of Turkey, ODTU TEKNOKENT's goal is to provide contemporary infrastructure and superstructure to the researchers and companies that develop and produce the technologies which will elevate the international competitiveness of the country. With its activities to facilitate university-industry collaboration, ODTU TEKNOKENT is the catalyst for synergy between the parties.
> With its more than 440 tenant companies, 70% of which were initiated in its premises and employ more than 10.000 personnel, 90% of which have bachelor, master of Ph.D. degrees, and with the 170.000 square meters of closed area reserved for R&D operations, ODTU TEKNOKENT has undersigned exemplary success stories to serve as a model for other technoparks in Turkey.
> The companies that are operating at ODTU TEKNOKENT are involved in R&D activities in software and information technologies (50%), electronics (20%), mechanics and design (15%), medical technologies (6%), energy and environment (6%) and advanced materials, agriculture, food, aviation and space, automotive that account for the remaining 3% altogether.
> Among some of the R&D projects carried out in ODTU TEKNOKENT can be counted, aircraft/helicopter systems dynamic modeling and simulation, aircraft/helicopter control systems development, satellite systems development, alternative energy and fuel projects, wind and hydro turbine design, vehicle tracking systems, test and measurement systems design, power sources and energy feed systems, lase applications, sensor technologies, tissue and genetics research, e-government, e-commerce, distance education, e-learning, and e-education software development, ERP-MRP solutions development, education management systems design, geographical information systems software, formatted message management systems, hospital software, advanced materials research and microelectromechanical systems design and application projects." (Teknokent, 2021)

Similarly, the CYBERPARK of Bilkent University has also been founded according to the Technology Development Zones Law with a similar administration organization schema, even though Bilkent University is a non-governmental educational institution. The institute has also shown remarkable progress in information-based research and practices in recent years especially in the development of interiority of laboratory environments whereas the exteriority of spaces with their eclectic architectural languages are subjected to criticisms. Thus, this is seen as specifically worthy of consideration with the spatial dynamics and the specific development policies in Turkey regarding the knowledge generation of collective and organizational practices that are busy with information-based practices.

Being among the plenty of related institutional research centers in ODTÜ Teknokent, Galyum Block, Silver Block, Modsimmer, and the Innovation Center can be introduced as the milieu for working on significant engineering studies and informational technologies, in short, in the organization of educated workforces. The research thus needs a solid inquiry on smart system infrastructures for such buildings to increase the creative subject and technology interactions. Artificial technologies are believed to enable the new interfaces of human-computer interaction for the research-related experimental actions of the educated workforces in the sites of research and development centers to reveal the institutional collectivity. Moreover, in the higher functional necessities of environmental inputs and user interactions for labs, offices, simulation centers, and research clusters, these research centers are believed to generate their Big Data further to find out building blocks of information on a particular behavior or research-related act. Therefore, the research arrives at a conclusion for the new possibilities of architecture's intelligence of creative evolution, which could lead to a new level of thought and practice for involving intellectual and academic environments with this inquiry on intelligent research environments in the information-based knowledge generation.

The desire for scientific knowledge territorializes the universities, and they have been perpetually deterritorialized by the scientific information, subjects of knowledge, and the flow of signs of communication. Universities produce the ultimate agent as the human infrastructure (Lacan, 2006a; 2006b) for the development of technology-based research and the Big Data of social spaces by closer interactions with the environment. In that regard, universities can be the sites for idealized spatiotemporal practices for the free will of truth by transforming science into knowledge and information of collective and social activity. Thus, universities also imply the social, cultural, and economy-political relations that shape the transformation of the spatialization practices (Sargın & Savaş, 2016) with the production of the knowledge and its subject. Scholars can argue that universities can generate overarching cognitive and spatiotemporal research and economic investments and social responsibilities with their influential spatiotemporal developments. Once one looks from this perspective to integrate intelligent learning spaces with the socially responsible larger-scale spatiotemporal developments, universities can provide infrastructural capacities for cognitive, spatiotemporal, and organizational transformation of science and technology in close proximity to production and society.

Describing the particular administrative and investment models of ODTÜ Teknokent and CYBERPARK in Ankara, the research believes that the extension of technology transfer via the development of intelligent environments for smart campuses will further provide larger scale investments and developments for further action in the urban environments. In the nearer future, technoparks are believed to give unique examples of the strong interactions among the organized, educated workforces via the generation of Big Data regarding the evolving dynamics of space, information, production, and technology in the creation of new institutional smart social spaces.

5.3. Concluding Remarks: Audience and Impact of the Research

The seminal study on the foundation of SenseLab in TU Delft has clearly indicated the potential usages of intelligent environments in that not only students, teachers, researchers, but also the public can benefit from experimentations and environmental test conditions (Bluyssen et al., 2018). In this regard, the development of smart spaces in university environments with certain academic expectations can have a wide range of benefiters. Corresponding studies can also help researchers and designers, including architects, engineers, and scientists who intended to develop intelligent spaces for research environments (Bluyssen et al., 2018).

This thesis, with all its premises and analyses regarding the study on the increasing works on intelligent spaces in smart campuses (Bluyssen et al., 2018; Valks et al., 2020), could get the attention of researchers and designers who need to develop smart spaces and need to learn new human-computer interaction relations regarding the environmental and spatial aspects. Furthermore, the research offers a comprehensive survey of the existing spatiotemporal, practical, and theoretical research, and could provide analytical implications with regard to the selection of methods, applications, and possible technologies in the development of smart campuses and intelligent spaces (Erişen, 2020a). Investigating the theoretical and practical concerns of human-computer interaction in close relation to the built environment could help researchers to understand the necessities of new state-of-the-art technologies and evolving relations among humans, technology, and the environment.

In that respect, the analyses of cases, used methods, and applications, as well as decision-making models for intelligent spaces and smart campuses in this research could help university administrations and policymakers in the development of university environments via intelligent learning spaces. Furthermore, due to the content analyses of the related works in this thesis, the researchers in cognitive and behavioral sciences could benefit from this research with the concerns regarding the evolution of the modern built environment with new technologies.

The research on smart campuses and decision-making models using IoT applications, for instance, help policymakers and administrative organizations of universities and even decision makers in planning and management of the spaces allocated for the development of intelligent environments and smart campuses (Valks et al., 2020). The related work has also surveyed different types of IoT applications that are beneficial to technology developers and researchers that need to learn from experimental cases. The research data of similar works, in that regard, can also give the ground truth for the development of new and state-of-the-art technologies developed for particular experimentational spaces and intelligent environments.

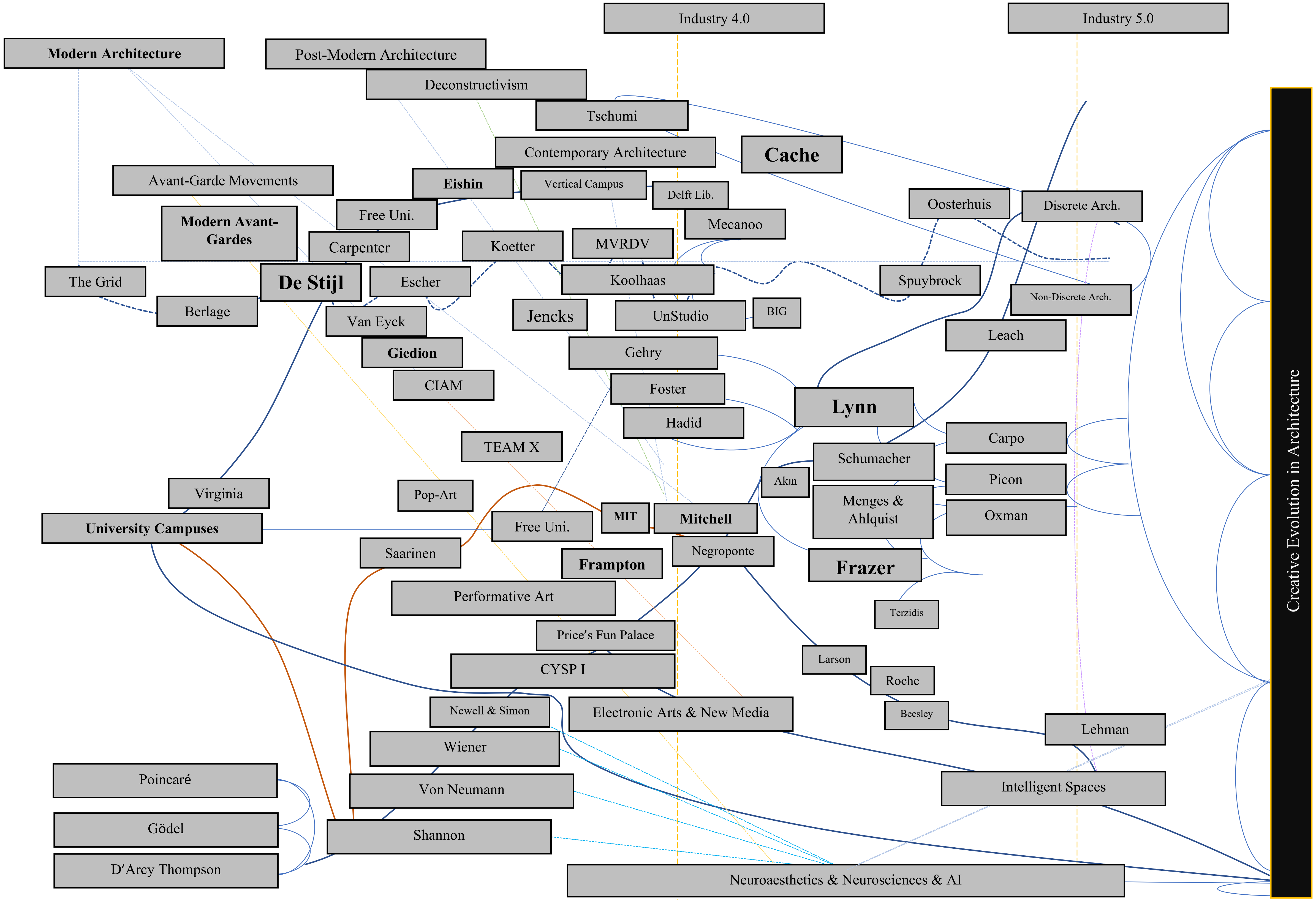
The existing examples of some smart spaces as well as experimental laboratories in the university environments, on the other hand, still indicate that there can be further endeavors to fully integrate the capacities of sensing networks and intelligent spaces with new Subjectile-Objectile relations regarding these impactful developments. With the compelling interdisciplinary research for intelligent spaces, technology transfer between agents, environments, and investments in research environments can be turned into innovative learning environments.

Based upon these arguments, the research also implies new teaching experiments in academic environments. This can be seen as necessary when regarding the rise of online learning as a challenge to the spatiotemporal experiences in the academic environments, as mentioned in the third chapter. In that respect, regarding the new necessities of the rising informational development for education and teaching in academic environments, the development of intelligent environments in academic spaces would be novel for both academicians and students.

The intelligent spaces in the university environments are also open to being integrated with interactive educational processes, demonstrations, lectures, activities, exhibitions, and workshops for and with the volunteering researchers and students. This is not only significant in new teaching experiences for both academic staff and students in university environments but also important in crowdsourcing, documenting, and assessing the learning outcomes, research methods, and practices, indicating the necessity for smart spaces in interdisciplinary research. Furthermore, the developments of intelligent environments, especially in academic environments and spaces with institutional engagements also have the potential to be developed further for learning new Subjectile-Objectile relations.

In brief, this chapter evaluates the concept of intelligence in new spatiotemporal practices and creativity in new Subjectile-Objectile relations from an evolutionary perspective. In this research, creative evolution in architecture can be seen as a containing concept and grounding work to constellate and implicate these spatiotemporal, practical, and theoretical aspects. It helps to understand the new Subjectile-Objectile relations with the necessary growth of intelligent spaces together with the concern over collective behavior, experimentation, and knowledge (Table 5.1).

Table 5.1. Creative Evolution in Architecture as a containing concept



CHAPTER 6

CONCLUSION

The inspirational ideas of Henri Bergson on Life, creativity, creation, evolution, and intelligence (Bergson, 1998) have been re-evaluated in this thesis as the containing concepts for creative evolution in architecture. In this research, the concept of 'creative evolution' is assayed to redescribe the multilayered relationships between humans, technology, and the environment in architecture throughout the generic theme of intelligence. Accordingly, the thesis hypothesizes these relations among humans, technology, and the environment as topologies to generate new cognitive, collective/organizational, and spatiotemporal inquiries. The subject of architecture in the contexts of technology, production, and design relations is questioned for a mindset of the creative and intelligent act in agent-to-agent interactions by the inquiry upon the critical role of collectivity throughout the concepts of Subjectile and Objectile, as primarily evolved by Industry 4.0. Furthermore, the study has questioned how architectural theory has also evolved simultaneously with the built environment to inquire about periodic architectural mainstreams and references. The research concludes the potentials of intelligent spaces, learning environments of scientific and academic institutions, and smart campuses in the collective understanding of the new relations between Objectile and Subjectile that can be found as a critical form of intelligence; and can be creatively read in the evolutionary dynamics of the built environment.

The thesis reads architecture as an ensemble of adaptive learning for the epistemological understanding of historical materialism for the actual mode of remembering as well as 'the immanent praxis of thought'. Thus, the whole thesis can be understood as a project for learning examples and modalities, conceptualizing and clustering relations, and producing new hypotheses to test the new conditions, as well as unknowns and challenges to an evolutionary research agenda of architecture. This approach can be seen as strongly inspired by the common features in human learning and advanced deep learning in artificial intelligence to regenerate itself by the ascribed meanings of creative evolution. Accordingly, the thesis enumerates the problems and potentials of the creative subject with the rise of artificial agencies and collective organizations in spatiotemporalities all together towards Industry 5.0 as a challenge for the learning profession. The study thus puts the challenge of interfaces of Subjectile and decision making in architectural production in question through the theoretical and analytical explorations for common research between the creative subject, architectural technology, and the built environment.

With respect to these inquiries, the study primarily finds out that the difference between the living and non-living systems is much more distinguishable by the interaction of the living behavior with the artificial. This complexity coexists with the correlations between the performative action and the affective behavior as a distinct feature of intelligence. It is also prominent to define architecture and its built environment concerning the correlations and distinctions between the human and the artificial with regard to the evolutionary change of production, technology, and organization relations. The intelligent and creative togetherness of natural and artificial agents is also seen as significant to deal with the voracious politics of the neo-capital competitiveness without generating further social and economic problems of the anxiety of effectiveness and unemployment, respectively. It can be considered that the rise of technology offers new thresholds to agent-to-agent interactions in Objectile-Subjectile relations, and it is possible to imagine novel collective organizations of architect-subjects and technologies.

In the multiplicity of many decision-makers and emerging environments, the analysis of Objectile's and Subjectile's spatiotemporality with the agency of architectural 'subject-object' should contract with the statement that 'Architect is the creative, social, and environmental agent'. The relation of the subject with its immediate environment in creating constructed values and meanings as the social agent with perpetual transformations should be primarily regarded in the (re)definitions of Subjectile. Thus, the human subject and his/her creative activity of mind at the intersection of Subjectile and Objectile contain the subjective preferences and their productive-material characteristics and values. The subject's decision making still distinguishes itself from the optimized artificial agent and from the parameters of Objectile. This necessitates a biological and psychological form of substantialization of consciousness in identifying and clustering things as well as intelligent and conscious decision making (Bergson, 1998, pp. 177-185) against social and spatiotemporal challenges, even as a performative activity. Thus, correlations with the artificial agencies also reveal the distinctions of Subjectile with the potentials for the freedom of the choice of the individual in decision making.

The circulation of Objectile, as the sublime object of the global production, always displaces and replaces the construed relations between the actors of production and information, still controlled by the turnover time (Harvey, 1989), which indubitably explains 'the division of Subjectile' (Cache, 1995)[123]. Thus, the question can also be maintained by the reciprocal modalities of Objectile and Subjectile by searching for the production parameters, use, and exchange values. In that regard, the thesis arrives at certain conclusions that it is first to overcome the hysterical sign values attributed to architecture by the capitalist production, to overcome the division between the meanings of Subjectile (Cache, 1995) and production for praxis. The second objective indicates creating or initializing innovative dynamics (like motion/movable) and the architectural subject-object characteristics as the '**New Objectile**' overcoming the divided relations between subject and object. Since the division creates infinite relations of parameters and units of dominated relations, the idea of integration of subjectivity and objectivity, conversely, comes up with a higher definition of creativity and its necessary interfaces on the possible creation of a 'higher thing' as a subject-object by the '**New Subjectile**'. The new Subjectile must be analyzed in the new potentials of architectural technologies with the immediate intermediation between subject and object, and in agent-to-agent interactions, and by the emergent parameters of performance and intelligence. Certainly, this will give us the peculiarity of the coherent form of the 'New Subjectile' with the help of the new human-artificial correlation in the freedom of conscious decision making of the subject.

[123] Bernard Cache refers to a psychological and philosophical interpretation of the subjectivity 'by the division' in the evaluation of the real, the symbolic and the imaginary with regard to the flows of production (Cache, 1995).

Accordingly, the study proposes that the togetherness of Objectile and Subjectile by the strong correlations between the human-artificial interaction is the inimitable way to construct 'New Objectile' and 'New Subjectile' as perpetually updated references by overcoming the ideological biases of 'Subjectile' and 'Objectile'. The 'New Subjectile'(s) can only be trained in the form of intelligence through performance and Affect relations that we attempted to explained in terms of the peer-to-peer relation of artificial agents' actions. The multiplicity of decision-makers and singularities of their negentropy-related attraction and diffraction points in the environment, thus, reveals the challenge of discrete modalities. Those singularities, then, can only be understood via modeling creativity and intuition in non-linear dynamics. Thus, the rising complexities in the collective action of the natural and artificial agencies in the built environment correspond to the research domain of what ought to be analyzed in the further necessity of *'Creative Crowdsourcing'*. This modality urges one to deal with the existence of multiplicities of many agents and their modalities in decision making. Hence, the complex emergent modalities and creative interfaces between the multiplicity of agents and environments imply the 'New Subjectile' and the binding motivation of the desired goals of architecture.

These novel collective organizations, on the one hand, can be formed as considerably small clusters of people that would deal with state-of-the-art technologies and information-intense knowledge generation, as they can either be central or concentric in a strategical organization; on the other, the general tendency of people might be adapting to architectural technologies' evolutionary dynamics in a more extended period. Nevertheless, scheduling this period too much, once again, would tend to carry the risk of further segregation from the technological and so the general organizational dynamics on the opposing side. Similarly, it is strongly possible to regard further segmentation and fragmentation of neo-capitalist task definitions with less-paid, less-skilled labor that may face the decentralizing challenges of the built environment such as pollution, population, noise, and even poverty due to the same dynamics. Against such extremities, this study has investigated the means and potential grounds of human-technology-environment relations so as to evoke certain forms of cognitive and organizational intelligence in the way of grasping collective creativities and architectural technologies. The studied key concepts, as a mindset, aim to blur the sharp distinctions of professions, technology, and competitive role definitions of the neo-capitalist tactics and strategies to generate such collectivities. Thus, the generative multi-agent systems and creative crowdsourcing for architecture are methodic endeavors for the dynamics of adaptive intelligence and creativity in the way of forming collective organizations, as in the case of smart campuses.

Briefly, regarding the organizational and epistemological challenges of the upcoming ages' rising technology and human relationships, the study envisions overcoming the polarity between the discourse on superhuman, on the one hand, and the sole spirit of collectivity on the other. As Castells implies in his *'The End of Millennium'* (Castells, 2000), the study investigates the 'social mode' of intelligence for the togetherness of the self and collectivity beyond the sole emphasis on the superhuman or collective spirit. Accordingly, this study investigates the potentials and limits of the architect-subject's coexisting situation with the technological evolution with a greater impact on architecture. Thus, inspired by actor-network theory (Latour, 2005), the study redefines the architects of the new age not as individual agents but as members of a team, as connected informational agents gathered around certain collective targets.

Moreover, the initiatives to explore the possibility between the actual technological capacities and the design of tectonics for futuristic experiences of such 'Intelligence' also generate architecture's autonomous discourse. It can be strongly claimed that architecture can become eligible to decide on the design of environments as the testbeds for scientific research, new technologies, and new means of production. Such growth is expected to necessitate the built environment for the interaction of natural and artificial agents through an environmental intelligence seeking the complex means of natural computation, which makes further technological advancements possibly revolutionary for architecture. Concerning the redefinition of this intelligence in the cognitive and organizational sense, collective awareness and even alliance among many different professions about the technological advancements is consequential to decide on these future dynamics.

This idea once again calls for a complex topology between the individuals, artificial agents, and the environment regarding the complexities of Objectile and Subjectile through space-time conceptions. The relative definition of intelligence, in that regard, proposes the togetherness of humans and technology to create unified collectivities with transformed cognitive thresholds and organizational forms of creative subjects. Novel means of computation like neuromorphic chips and the growth of technology, for instance, only imply the current potentials and the future for new Objectile; and they can play significant roles in the possible interactions of intelligent spaces. Thus, the research reaches a conclusion that topologies among the human-technology interactions would further be reinforced with the built environment and by its transformations with overarching research on the evolutionary trajectories of creativity and production-related paradigms. This concludes the new interpretations of Objectile and Subjectile that ought to be learned in an evolutionary transformation of production relations in the built environment we live in, extending from modernity to technological intelligent spaces.

Corresponding to this inquiry, the role of creativity implies the evolutionary trajectories of avant-garde movements on the one hand; on the other, the built environment implies modern architecture's evolutionary culture with the multiplicity of different industry- and production-based relations and movements. They also confer to some epistemological bases and knowledge production, and this is directly related to the sites of knowledge production; that is, university campuses. This inquiry reveals the relationships between the knowledge of architecture, the evolutionary trajectory of industrial revolutions, and technology that turns into the practice of collective making and thinking. Hence, the first apparent paradigmatic turn can be attributed to the evolutionary transformations by the precedent industrial revolutions before Industry 4.0. These aspects correspond to the internal dynamics and oppositions of the modern way of practicing and thinking, *per se,* starting from the first industrial revolution and giving rise to modernity.

However, the second distinct paradigmatic turn can be read through the interpretations of scientific and technological advancements on the instrumentalization of design thought and practice with regard to non-linearities and the flowing relations in non-standard production. Accordingly, the second and epistemologically different agenda of practice and research reveals the role of Industry 4.0 in the definition of 'Objectile'; and allows us to better understand the confluential togetherness of the first and second turns of creative evolutions in architecture. Yet, it is critical in this survey that the lack of emphasis on the role of universities in the second confluential turn can be regarded as missing research. Therefore, this finding deserves to be studied further with the theme of intelligence; and can help us reach other paradigmatic turns, especially regarding the future of research university campuses. It is concluded from this research that the discourse on the spatialization of the shift in science and technology affecting spatiotemporal practices has barely been reflected in the design of research campuses. This argumentation is open to novel interpretations of new paradigms with the rise of technology, and human and intelligent environment interactions. In this regard, it also becomes possible to introduce the missing ties between the discourse on Objectile and Subjectile with modernity and their spatiotemporal, epistemological, and organizational relations in the dynamics of intelligent spaces and smart campuses. Accordingly, the research analyzes further implementations of intelligent spaces under the collective and organizational capacities of academic and research environments.

The integration of intelligent infrastructure and the built environments in the production of creative and critical collectivities by research campuses promises novel potentials of the concept of intelligence that the attempt is made to describe regarding unified organizational and epistemological contents. It is among the premises of this research to regard the informational human-technology-environment topologies towards unified endeavors of the futuristic singularities of Objectile and Subjectile. Hence, spatial computing [124], as a generic platform of decision making and policymaking, might have potential resources for revealing the new dynamics of subject-technology-environment interactions. Respectively, some outcomes of this research with the expectation of novel organizational and even educational reflections can be summarized for further inquiries as follows:

- The study finds out that spatial computation agencies for human-environment-technology topologies can only be designed in the complexity of many-body systems under non-linear and even the catastrophic dynamics of environmental, artificial, and subjective singularities (like computing with negentropy). Consequently, the decision making of architecture and programming

[124] *Computing the Environment* has seminal articles to derive similar concepts (Peter & Peters, 2018).

spatiotemporalities can be evaluated regarding the design of spatiotemporal attractors for spatial computing. The complexities in decision making and particular dynamics of Subjectile can be crowdsourced with the new spatiotemporal practices, applied through recent and emerging technological possibilities of IoT and new generation state-of-the-art technologies.

- The future of technological, science-based, and information-intense production is supposed to affect subjects' cognitive and spatiotemporal organizations. The spatiotemporal reinforcement of creativity-technology relations and the grounds for epistemological endeavor can be achieved first by the sites of production of knowledge: the university campuses. This finding does not appear in the recent discourse of the digital paradigm in architecture. Intelligent spaces in the future of campus environments of Industry 5.0 have substantial grounds for the next paradigms and epistemological endeavors, respectively (Table 5.1).

  The developments of scalable quantum computation means are favored by significant research institutes, like TU Delft, based on industry-university corporations and technology transfers. Therefore, the campuses can become the grounds for large-scale scientific experimentations (Figure 5.1). It is possible to propose policymaking parameters to augment the level of technology transfer for the rights of academic and scientific research and education with their spatiotemporal organization patterns via smart learning spaces. The future of the academic and practice-based learning environments and campuses of Industry 5.0 should be designed accordingly.

- Research outcomes for the new scientific and technological developments of intelligent spaces and learning environments of scientific and academic institutions even in smart campuses, can generate new Subjectile-Objectile relations. The repercussions of these changes can also reflect back to the cognitive and spatiotemporal organizations and the way they produce knowledge once again. Similarly, the future of Objectile and new means of crowdsourcing can be based on advanced algorithmic iterations when regarding the complex networks of urbane singularities. The sensorial networks for 4D printing, natural computation, neuromorphic computing chips, or ecologies of energy-substance-information conversion with emerging quantum computation technologies imply the potentials of smart spaces, including new Subjectile-Objectile relations. This may enable the design of spatial computing attractors, and give substantial results to develop further endeavors of creativity in close connection with architectural technology.

Other than all these long-term projections, the short-long term possibilities should integrate technology with architecture and its subjects to practice intelligent environments. As there are scarce plots and mediocre/descending needs to the construction and the built environment, especially in metropolitan areas, the actual needs have also been oriented towards the regulation of existing spaces by intelligent infrastructure, intelligent systems, and smart grids. They also help to coherently systematize a new design approach with decision making by the futuristic endeavors of urban computing. Information-based tectonics of smart grids and intelligent infrastructure can even be applied to modernist buildings and in the renovation of the historical ones for transforming the built environment with energy-efficient retrofitting (de Wilde, Spaargaren, 2019). Architecture, after construction as a service, and the relative development of skills, can similarly be expected to control the environmental feedback, the usage of the architectonic elements, the rights on the changes of tectonics (like the property rights), and their maintenance. This possible near-future is envisioned as an architecture that updates itself (Kim, Kim, Cha, Fischer, 2015) with the coexisting control of the built environment with technology as a creative evolution. This approach can also be turned into a scientific and autonomous domain in the inquiry of intelligent learning environments. It will also give immense feedback from Big Data for the new/updated design solutions; and can offer new job opportunities, skillsets, and organizations to architects.

Nevertheless, the thesis claims that the actual evolution is even yet to come. The asymptotic change can show itself by the transforming ideals of humanity with technology and nature towards a “radical abundance” (Drexler, 2013), and in the prevention of the natural and social challenges (climate change, destitute), or at least in the betterment of them (Snell, 2018, pp. 88). The disasters, diseases as in the rise of COVID-19, abrupt changes in ecologies, the natural and artificial forces beyond monotonous evolution of Life only require in-depth parametrization of different factors that may not be comprehensively evaluated without understanding their non-linear relations and corresponding topological complexities. Designing each architectural element as an informational component and the design as a compilation of the system as an evolutionary configuration would help to construct sustainable developments with such unified aims of humanity. For instance, designing smart spaces for people in need of care having Dementia, Alzheimer's disease, or types of cancer may require particular parameters such as considering optimization of operational time in treatment progress, as in the ones of stem cell operations (Fillon, 2018). After the rise of the COVID-19 pandemic throughout the world, intelligent spaces with smart health applications, as well as optimized systems, have also become much more necessary with the rise of smart health applications for smart cities and spaces for healthcare (Ding et al., 2020; Habibzadeh et al., 2020; Moslehian, Kocatürk, Tucker, 2020; D'Aeth et al, 2021).

The development of new technologies would also give the designer immense potentials and responsibilities in decision making and crowdsourcing of the environmental entities. The new generation of quantum chips, quantum networks, quantum computation, and quantum communication, or the increase in the efficiency in superconductors, or the challenges of scalable chips that can work at cryotemperatures (Bertels et al., 2018; Almudever et al., 2019) reveal the substantial endeavors towards the commercialization of such future technologies (Ding et al., 2020). Among the historical and futuristic landscapes of (data and) actions, such an outlook is realizable, and we can explore the event horizon of those potentials for intelligent spaces in smart campuses.

The development of new technologies can also be the new endeavor to discover the potentials of the universe and its epistemological knowledge that the five senses of humanity cannot determine/presage. Generating novel grounds of phenomenology other than our five senses with the help of artificial agencies for those challenges will give us the recipe for the future of technological advancements and the new Objectile, on which the new Subjectile will be developed. Advanced studies such as holography, supergravity regarding the sub-theory of 11-dimensional supergravity for M-Theory; or the existence of dark energy and dark matter still wait to be reinforced with phenomenological facts as a challenge (Hawking & Rocek, 1981; Hawking, 2002; Susskind, 2005; Maldacena, 2005; Becker, Becker, Schwarz, 2007; Dawid, 2013;

Devecioğlu, 2016; Alexeev, 2017). Those endeavors between the epistemology/theory and phenomenology/experiment can even enable us to think about means to discover dark matter and dark energy in the perpetual transformation of science and technology that are not available to our senses and perception 'even in the expansion of the Standard Model' (CMS Collaboration, 2008; CDF Collaboration, 2019).

Such inquiries can be described under the scope of environmental and technological challenges besides the new and instantly interactive production means in architectural technology. Including the new superconductive technologies integrating the self-sufficient and self-organizing scalable chips, technologies, natural agents, and computers in design could represent one example of this inquiry. Further creative thinking on these inquiries may enable having versatile research agendas, architectural technology, educational premises, and professional practices to grasp the cognitive, organizational, spatiotemporal, and epistemological repercussions of these modalities. Intellectual and political considerations regarding the aesthetic qualities, discourse, education, novel language constructs, and the organization of collectivities include even far more complex challenging intricacies. Thus, architecture should be aware of those challenges in advance for its socio-economic and cultural roles to design environments (Luebkeman, 2015). Some challenges can be listed for the creative researchers and learning actors of architecture's future, who will be supposed to be aware of the evolutionary dynamics of engineering, science, creative culture, and ecologies of spatial computing regarding:

- The new mindsets to grasp the togetherness of architecture, technology, and urban environment with creativity to define new means of practicing, education, and theorizing architecture;
- Definition of evolutionary dynamics of intelligent spaces and smart grids (Christopher, 2015);
- Finding challenging parameters of non-linear and discrete modalities for evolutionary transformations from smart grids to sensorial infrastructure (Erişen, 2020a);
- Advanced human-element interactions, and the search for artificial consciousness: the role of artificial agents that explore the conscious states of mind, the relations

of the negentropy of subjects, and the possibilities of artificial senses/consciousness other than the five senses and biophysical substantialization;

- Learning environments (by the informational basis of Spatial Computing) (Lehman, 2017; Peters & Peters, 2018) as experimental testbeds for wave-particle duality and interactions of challenging uncertainties (Ballif & Dibble, 1969; Becker, Becker, Schwarz, 2007);
- Ecologies of informational and material conversions and transformations (with superpositions, entanglements) (Wilde, 2013);
- Sustainable environments via efficient energy conversions/retrofitting (regarding the poor region conditions), and carbon-efficient environments (regarding the ecologies of photosynthetic reactions, entanglements, energy-efficient conversions, and communications) (Resilient Urban Ecosystem (RUE) Network, 2016; de Wilde & Spaargaren, 2019; Megacities project, 2020);
- Sustainable environments of global metropolitan spaces (regarding the condition of collectives of architects, overpopulation and overpollution, and health conditions, even by the analysis of molecular computing on bacteria and diseases);
- Design concerning endemic (authentic -pure) nature and healthcare conditions (analysis of bacteria, photosynthesis, and their entanglements) (Chu, 2019);
- Creativity in high engineering, like aesthetic considerations of space-living colonies;
- Energy-efficient solutions with network capacities (with communication, computation, sensorial and atomic/molecular infrastructures) by applied energies (Bui, Nguyen, Ghazlan, Ngo, Ngo, 2020), as in research over energy ecologies reporting the usage, incident energy, as well as future predictions and environmental interactions towards the artificial computation of cities after the 2040s (Kocatürk, 2017);
- Super-performativity of materials (smart or switchable nanoscale gates (Zhang, 2021), superconductors, superfluids), structures, and subjects;
- Challenges of higher dimensional Objectile/Subjectile interactions/productions by 4D printing, evolutionary smart grids, Digital Twins, form-matter relations (self-reproducing technologies of superconductors and superfluids via stereotactic

control) (projected through complex unsolved problems and with complex interrelations through higher-dimensional manifolds) (Connes & Marcolli, 2008; Ivancevic & Ivancevic, 2012; Drexler, 2013);

- The challenges of negentropy (Azuma & Subramanian, 2018) in the organizational aspects and the design of spatiotemporal attractors;
- Design and decision making about spatiotemporal attractors of human-nature-technology topology and intelligence of smart spaces and many-body systems.

Briefly, this thesis can be claimed to be organized as a model of learning research agenda for architecture. From the topology of human-nature-technology**,** it is possible to find a paradigmatic evolutionary algorithm (or mapping) for this recurring research, returning creative and yet evolutionary loops by possible singularities as a **dynamic research program that reproduces itself** for the future of creative evolutions. Accordingly, from the challenges of decision making towards the design of sustainable and social environments with the future of science and technology (Brandon, Lombardi, Shen, 2017), the scope of this inquiry may reveal further reviews towards the novel intellectual paradigms and their intelligence-based phenomenological challenges. The inevitable advancements in science and technology promise to affect the cognitive, spatiotemporal organizations in the built environment as a singularity for an evolutionary research agenda.

In conclusion, creative evolution in architecture is supposed to stand as a search for encompassing and critical agenda of thought and practice in architecture and the built environment regarding technological advancements. The future of campus environments, as well as the novel production technologies, integrating new generation computers, intelligent infrastructures, and crowdsourcing methods, present such common grounds to proceed further on the axis of the unified grasp for creativity and consciousness as a form of intelligence. New Objectile-Subjectile relations would also generate novel confluential paradigms and the politics to be learned. This thesis envisions this ever-evolving, discrete, and non-linear-dynamics-with-alteration under the generic theme of 'creative evolution' in architecture.

As a closing remark, the collective unity of new organizational and epistemological endeavors like developing intelligent spaces within and throughout university campuses can even generate forthcoming paradigms. The ongoing processes of capitalism, on the other hand, would generate dialectical polarities for new distinctions via new production and subject relations. Nevertheless, the emphasis on unity as a form of intelligence can be organized by spatiotemporalities to learn the unified endeavor of different research domains. It is claimed that such research is still open to further creative and political readings to identify singularities, and to develop unified and dialectical resolutions of future studies.

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APPENDICES

A. APPENDIX FOR CHAPTER 2

Table A.1. Binary code table and its equivalent ASCII code for the sole word ‘ARCHITECTURE’

ASCII Code	065	082	067	072	073	084	069	067	084	085	082	069
The Word	**A**	**R**	**C**	**H**	**I**	**T**	**E**	**C**	**T**	**U**	**R**	**E**
Binary Code	01000001	01010010	01000011	01001000	01001001	01010100	01000101	01000011	01010100	01010101	01010010	01000101

Exemplar model development for interacting interfaces: The learned data structures of modeling software and learning models can be turned into generic bases to execute solutions for predicting and suggesting the activity of users; or for the decomposition of human expectations and design elements in correlation. This necessitates shared values and amplitudes between the subject and computer logic; and it is only possible to determine eigenvalues and eigenvectors to decompose the relations and elements of learning into expected entities. Then, the development process speeds up immensely with the corresponding directionalities of possibilities.

Selecting efficient learning models and the implication of the backpropagation mechanism can be conditioned with regard to the parameters of precision, accuracy, specificity, sensitivity (recall) (Table A.2). Such correlational models necessitate to put forth the distribution of each data with regard to Z score (in the computation of each data value x with regard to the mean (μ) of all data and the corresponding standard deviation σ as $Z= ((x- \mu)/ \sigma)$; and necessitate the assessment of F1 score for each model (or/as agent’s performance) to get the correlation between the human and artificial agent or between different artificial models. This part also relates to developing correlational likelihood functions of performance between different agents. There can be an increase in agents' performance and learning rates, as the artificial agents learn the progress by the plenty of experimental datasets.

Similar models can also be developed by genetic algorithms besides considering neuro-fuzzy models and metaheuristic algorithms, like evolutionary algorithms or optimization methods. Because they are common in the evolutionary interactions between human and the logic of modern computation; and useful to generate new data by the crossover of information between different agents and informational cultures by the probable selection. Genetic algorithms can also be used to find out the optimum (maximum or minimum) values that are swapped and mutated from different bases/agents (S.L. Brunton & Kutz, 2019); as even inspired from molecular operations like the gene drives, gene vaccination, and manipulation as a method for evolution (Noble, Olejarz, Esvelt, Church, & Nowak, 2017; Esvelt, 2019a; 2019b).

Table A.2. The parameters of Precision = TP/(TP+FP); Accuracy=(TP+TN)/(TP+FP+TN+FN); Sensitivity (or recall)=TP/(TP+FN); Specificity=TN/(FP+TN); F1 score= 2*((Precision*Recall)/(Precision+Recall))

	(+) Positive prediction/action	(-) Negative prediction/action	(+) Positive prediction/action	(-) Negative prediction/action
	Model 1 / Agent 1		Model 2 / Agent 2	
Evidence of Action (+)	True positive 1 (TP1)	False negative 1 (FN1)	True positive 2 (TP2)	False negative 2 (FN2)
Evidence of Action (-)	False positive 1 (FP1)	True negative 1 (TN1)	False positive 2 (FP2)	True negative 2 (TN2)

The utilization of artificial neural networks, on the other hand, has fewer cost issues and is good at accuracy and robustness in the computation of data. The correlation of the learning neural networks with human reactions can augment the representational workspace developments and the skills of the agent as a form of intelligence. By deriving certain likelihood functions and performance scores by the correlation of the action of the agent and the learning progress of the artificial media, following the reactions of the target agent, artificial media can replicate and reinforce the target agent's activities; and yet reveal the unique features of the Living beings, like Subjectile, which the artificial agents cannot mimic. On the other hand, technological means can also take over the creative capacities that human agents cannot realize, like dividing inherent data into implicit and discrete forms; and like the creation, annihilation/abortion, and re-creation of recursive neural networks.

Assume that there are assessed features/actions for each agent ‘as correlated binary data of 0 and 1', and they will be associated as a model through genetic algorithms. The states of data that each agent has in the crossover and selection process for the next generation (of information) of probability function are depicted in Table A.3. Assume that there is executed crossover of genetic data on the features: f4, f5, and f6. There would be newly generated data by the crossover of different bases with 2^{10} different possible variations. The likelihood function of features in between agents defines the probability of the selection of the dominant features as an optimization activity; it is possible to maximize the feature outcomes by selecting 'the desired strings' without trying all variations (Table A.4).

Table A.3. Exemplar table for Genetic Coding/algorithms and Crossover/Mutation Operations

Features/Actions	f1	f2	f3	f4	f5	f6	f7	f8	f9	f10
Agent 1 data 1	0	1	1	0	0	1	0	1	1	0
Agent 1 data 2	0	1	0	0	1	1	1	0	0	1
Agent 2 data 1	1	0	0	1	1	0	0	1	0	1
Agent 2 data 2	0	1	1	1	0	0	1	0	1	1

Replication & Crossover	f1	f2	f3	**cXf4**	**cXf5**	**cXf6**	f7	f8	f9	f10
Agent 1 data 2	0	1	0	1	1	0	1	0	0	1
Agent 2 data 1	1	0	0	0	1	1	0	1	0	1

Table A.4. Selection by Crossover

Selection by Crossover	f1	f2	f3	**cXf4**	**cXf5**	**cXf6**	f7	f8	f9	f10
New Generation Agent 1-2 data 1-2	1	1	0	1	1	1	1	1	0	1
Feature strength (Exemplar Probability)	0.78	0.96	0.12	0.86	0.99	0.84	0.73	0.56	0.21	0.97

After the exemplar selection of data, features f3 and f9 are in need of growth, whether by 'Agent1 data1' or by 'Agent2 data2' according to other possible new generations for the optimal results. There can be found further classifications and variations between those features/data such that combinatory compounds of each value would give a decision for indexing higher class features and elements, as in Table A.5. Additionally, there are other variations such as the mixed states of {F V = [f3, f8, f9]} to search for good parameters either by exploring the memory/pool of features/data (genetic pool) or the mutation of features (parameters of performative acts).

Table A.5. Higher Class of Feature Indexing

Higher class of features	F I			**F II**			F III		F IV		**F V**		
Features	f1	f2	f3	**cXf4**	**cXf5**	**cXf6**	f7	f8	f9	f10	**f3**	**f8**	**f9**
Agent 1-2 data 1-2	1	1	0	1	1	1	1	1	0	1	**0**	**1**	**0**
Feature strength (Probability)	0.78	0.96	0.12	0.86	0.99	0.84	0.73	0.56	0.21	0.97	**0.12**	**0.56**	**0.21**

Further model developments can be executed for the evolutionary protocol over the models or contracts. It can be assumed that systems can renew and update themselves by coherent data supply; and can detect errors, novel actions, and features as forms of optimized learning between the supervised and unsupervised modes. In addition to this, there can be novel generations, modifications, and adaptations to the consistent data sources. The external feedback and internal propagations can achieve further reinforcement learning as an update through that protocol in connection with the environmental sources, effects, and the internal belief of computation.

A much more classical neural network system can correlate actions similar to the other agent's measured activity. The flexible neural network systems with the arbiter between the two agents, connected to sensorial, environmental sources, and the evolutionary protocols, can found alternative models and associations during the performative actions. With respect to the capabilities of neural networks, the change in learning type (by changing its circuitry and operating the data through its gates) can also be expected as a feature of such systems. Additionally, there can be the local specialization of modulations (as functional change of neurons by the controlling operations through circuits). Such circuits are assumed to have error correction capabilities so that acquired data can also be propagated back to its sources without any error/problem. The association of such networks can give possible flexibility beyond designing performative correlations. The looping reactions between action, recognition, learning, understanding, and decision-making can be derived from the types of neural networks.

There can be arbiters between different artificial agents; or between the artificial agent and the interface that the individual uses. Thus, the complex human behavior can still be replicated by other creative artificial informational platforms; and it is also possible to explain them by real-world application scenarios. Software can also create functions, methods, and constructors by listening the learning events and user activity.

■

Review on Neural Mechanisms for Computation: Artificial neural networks can mimic the natural agent's behavior for its motor reactions; and handle the events in action by learning the cortical, somatosensorial, and motor reactions. The elements of neuroscientific computation dwell on the spiking neurons and threshold mechanism by the stimuli, that is inspired from the behavior in $Na^{-} - K^{+}$ pump for the interactive axon-dendrite relation of 'the long-term potentiation and long-term depression mechanisms' (Spitzer, 1998). The electrical transmission, additionally, can be parametrized by speed, noise, and plasticity by electrochemical interactions via the modulatory mechanisms of active neurotransmitter materials within the cell (Spitzer, 1998). The intricacy of memory should also be investigated in the associative organization of those substantialization processes further as fluxes and facilitations. Besides the simpler electronic reductions of artificial mechanisms, it is crucial to investigate the generation of memory-based chemical and biological formations with the inquiries of combinatory mechanisms (even entanglement) by the advanced studies in nanoscience, quantum fields, and molecular computing (Landhuis, 2020).

B. APPENDIX FOR CHAPTER 3

The design of 'special' spatiotemporal attractors for human-computer interactions and spatiotemporal experiences is to be correlated with complex models (like likelihood functions). It is possible, then, to enumerate some logical states of experiences that would belong to the creative, subjective experiences; and the perception of technological/artificial agents of architectural environments. Modes/propositions of interactions between different agents can help to correlate as well as distinguish and evaluate the emotional fluctuations and changes, or 'relativity', in the aesthetic perception of the subjective agents; and to find out an artificial basis for the aesthetic experiences, which will be analyzed/described here through 'entangled connections' (Table 3.1). Entangled connections can be seen as a further step, as an imaginary future of creative architectural technologies like 'Digital Twins' (Batty, 2018) beyond the human-artificial correlations. In entangled connections (similar to the experiments of measuring data of two different laser sources), each point occupies a state of mode: *S-basis* shows the subjective states and their fluctuations; *T-basis* shows the evolutionary progress that artificial agent(s) correlate with respect to the different states of *S* in time-series; and compare them with the exact experimentations (Table 3.1).

■

Once the interrelation between cause and effect and the prior and posterior evidence is not as straightforward as in the ones classical types of learning, the proposition of **likelihood functions** by **Bayesian estimations** and **modeling nonlinear** behavior patterns and parameters, as in the cases of **Lorentz attractors,** can help to find **probabilistic models**. This is one way of regarding the complexity of life and the dissolution of the chaotic relations/states in human-artificial-natural topologies that can have mutual relations or entangled correlations between states/actions/memories/agents (Table 3.3). Respectively, the corresponding mathematical/logical methods of the Bayesian estimation between the prior relations and the outcome require a series of analyses upon the conditioned knowledge, propagating the learning experience that is associated with memory. The priori, posteriori, and the conditioned probabilities then invoke a likelihood function that is to be found in integrating the prior and conditioned values. The questions for states, values, elements, and entities for challenges of flows and perturbations (of environmental relations), regarding the condition of the creative subject of architecture in correlation with technology, can ground for a new cultural/abstract set.

■

Regarding the relations between informational models and cognitive fields, **Izhikevich** occupies a very significant place in the scientific inquiries of computational neuroscience. With his seminal studies on modeling dynamic systems, bifurcations, and synchronizations from **Hodgkin & Huxley model**, it is also crucial to understand the dynamic and evolutionary perspectives in the field of computational neuroscience. Giving the foundational principles of **computational neuroscience** that are based on modeling the stimuli through thresholds and spiking mechanisms, Izhikevich's approach, hence, is singled out from many other studies by his seminal approach internalizing those principles with **the dynamics of nonlinear systems**. Regarding the properties, energies, and dynamics of electrophysiology by concerning the prominent models, like Hodgkin & Huxley equation and model (Hodgkin & Huxley, 1952), Izhikevich is one of the most significant scientific figures in the field of computational neuroscience. In his book, Izhikevich genuinely introduces bifurcations, saddle points, attractors, and the collective behavior of synchronization, which is seen, instead, as a complicated pathological issue. Because synchronization is observed in fishes' swimming patterns (Izhikevich, 2007). By mapping the phases (even the three-dimensional ones and complex n-dimensional manifold geometries) based on the principles of oscillation (like the movement of a pendulum) through nullclines and modeling attractors, Izhikevich explains his seminal approach:

> "Nonlinear dynamical system theory is a core of computational neuroscience research, but it is not a standard part of the graduate neuroscience curriculum. Neither is it taught in most math/physics departments in a form suitable for a general biological audience. As a result, many neuroscientists fail to grasp such fundamental concepts as equilibrium, stability, limit cycle attractor, and bifurcations, even though neuroscientists constantly encounter these nonlinear phenomena." (Izhikevich, 2007).

When a neuron fires two or more action potentials as 'the burst of spikes', the system is defined as bursting neurons (Ivancevic & Ivancevic, 2012) beyond the spiking neurons. The domain of nonlinear complexities in neuro-dynamics focuses on the (multiple) attractors in the systems (Ivancevic & Ivancevic, 2012), their bifurcations, and complex corresponding curvature geometries and manifolds as in the challenging case of Lorentz attractors. Similarly, the bistable (multi-stable) states can have coexisting attractors of neural-electrochemical force fields as Izhikevich defines (2007). Another possible fact is described via the jumping states between those different equities; and the possibility of one cells's state returning to the initial system and its initial state depending on its history, which is defined as hysteresis (Izhikevich, 2007).

■

In modeling creativity: Hoorn recommends using '**Sigmoid curve**' as a function to see the ruptures and leaps from continuous curvatures as particular 'jumps' or leaps (Hoorn, 2014). These ruptures can be modeled by hybrid versioning of science and math-inspired graphical modeling (Hoorn, 2014). There are also other common methods and functions for those **decision-making systems**, such as 'Softmax' (MATLAB, 2018), that are started to be used commonly in artificial neural networks, decades-old Markov decision-making equations, and in efficient models and equations utilizing **Monte Carlo methods** (MATLAB, 2018). Some modeling, based on neuro-fuzzy neural networks, can also define the memberships and reciprocal parameters for each different aspect so that different steps of clustering and regressions towards the expected solution spaces can be named as perception, learning, understanding, intelligence, and creativity processes. Bayesian estimation and likelihood function beyond the linear models of cause-effect relationships can be seen as best to describe the confluential leaps of conjunctions and disjunctions, or convergences and divergences, as methods of intelligence and creativity (Hoorn, 2014). It is necessary then to read those associations, correlations, and complexities via nonlinear functions and as differential evolutionary states and memberships. Beyond these simpler modeling, however, there can be encountered much more complex correlations that cannot be solved by simpler insertion of sigmoid curves. As described before, consideration of associative models and learning curves with the coexistence (co-occurrence) of different, simultaneous, and remote processes should be regarded as critical by grasping nonlinear models, convergent, and divergent procedures with respect to **Bayesian estimation**. **Chaos, complexity, and nonlinear dynamics** on brain mechanisms are the essential studies that focus on the unpredictable behavior of emergence of especially multiple (and even strange) attractors and the different directionality of physical/electrochemical force fields.

C. APPENDIX FOR CHAPTER 4

Euclidean and Non-Euclidean Geometry: It can be said that representational constrains of two-dimensional design screen/plane is still futile to identify vectorial forces as a mere representation of external binary data. These technologies still miss some potentials of topological spaces. About the ongoing debate on Cartesian versus topological space; and Euclidean and non-Euclidean geometry debate, there are innovative suggestions for unique theoretical (and possibly practical) arguments that are relevant for architectural practice in spatial organizations. Eiroa Architects declare the creative concept of Cartopological space between the Cartesian parametric space and the topological transformations regarding the common basis in digital architecture and the parameters of topological loops beyond the semantic representation (Eiroa Architects, 2013; Oxman & Oxman, 2014).

Beyond the simpler logic assigned to the computational interfaces, the laws of commutation, association, subtraction for addition, and multiplication between two vectors of *a* and *b* give the axiomatics on vectors and their interrelated conditions (Whitehead, 1971b). In Whitehead's book on *Descriptive Geometry* (Whitehead, 1971a), the axiomatic relations of those elements of space are constructed literally. Whitehead's study makes the axioms noumenally intelligible to us. Whitehead's book on *Projective Geometry* makes us further understand how the relations on geometric transformations and transference of relational geometries between different elements of planes and reference systems could be achieved via abstract geometrical and mathematical constructions by starting to explore from Dedekind's parallel postulations for further variations (Whitehead, 1971b).

The topological interpretation of the parallel theorem in Euclidean Geometry is seminally introduced in *Descriptive Geometry and Projective Geometry* (Whitehead, 1971a; 1971b), which did require internalizing the mathematical iterations. Lobačevskiĭ hypothesized the conflicting angles in a rectilinear triangle with infinitesimally small angular dispositions which reveal the paradox in Parallel Theory of Euclidean Geometry that resulted in imagining the curvature of space (Rosenfeld, 1988). Thus, Lobačevskiĭ did other than the accepted Euclidean principles of geometry (Rosenfeld, 1988). Bolyai simultaneously worked on the same discovery; he preferred to intuitively construct the parallel line with reference to the rays of infinite straight passing lines; and found out sinusoidal ratio to each angular relation that is called as absolute geometry, which fits Euclidean as well as Lobačevskian Geometry (Rosenfeld, 1988, p. 214). Hilbert theorizes the five axioms of three-dimensional Euclidean space as:

> "I, 1-8. Axioms of incidence, which define the relation "a point lies on a straight line", "a point lies on a plane."
> II, 1-4. Axioms of order, which define the relation of point to a straight line in accordance to its order to other two points that define the segments and endpoints of a line
> III, 1-5. Axioms of congruence, which define the relation of congruence of segments and angles
> IV, Axioms of parallels, is equivalent to Euclid's V. postulate as Euclid's parallel postulate that is challenged later, but non-Euclidean algorithms and
> V, 1-2. Axioms of continuity contain two axioms that one is Archimedes' axiom "for any two segments there is a natural number *n* such that if we lay off the smaller segment *n* times, then we obtain a segment larger than the larger segment". The second one is Cantor's axiom that every nested sequence of intervals accordingly has a common point." (Rosenfeld, 1988)

Thus, in the axioms of parallels, Euclid's fifth postulate (or postulate V) is alternated via the iterations of Lobačevskiĭ, Bolyai (Rosenfeld, 1988), and Minkowsky (Hight, Hensel, Menges, 2009) by recognizing the intricate relation of the curvatures in the theorization of non-Euclidean Geometry. Non-Euclidean geometry's emergence can also be based on the rise of Riemann curvature and its multidimensionality. This evolutionary progress led not only to the theorization of General Theory of Relativity by Albert Einstein but also to the interpretation of geometric rules and axioms with the multidimensionality of Riemann space by Hermann Minkowsky (Hight, Hensel, Menges, 2009). Further interpretations on the emergence of novel theories on geometry in relation to mathematics, physics, and astronomy have come from Poincaré's conjecture generating the three-body problem; and the theory of incompleteness by Gödel, which argues the impossibility of fully determined axioms for all geometric complexities (Retsin, 2019).

Poincaré also specifies the theorems of 'four-dimensional space' (Rosenfeld, 1988). From the sphere of the imaginary radius in the relation of points and vectors, Poincaré theorized a "pseudo-Euclidean space that hyperboloid played the role of the sphere of imaginary radius" and defined the topology as the qualitative (Rosenfeld, 1988, p 266).

The relation of points with vectors is constructed via n-dimensional affine space (Rosenfeld, 1988) by the 'Metrical Axiom' that uses affine transformations. The distance relations between points and lengths of vectors, accordingly, reveal the trigonometric and angular relations of elements in space. This actually gives the essence of non-Euclidean geometry that is based on the intricate relations reciprocal to spherical geometry; and generates paradox in parallel theorems (Rosenfeld, 1988). The history of spherical geometry and evolution to Special Theory of Relativity by the analysis of curvature of space by Riemann besides the studies on Topological Space by Poincare (Poincaré, 1913; 1962) enable to postulate transformation of time from one inertial reference system to another (Rosenfeld, 1988, pp. 265-317). Thus, the mathematical definition of topology reveals the level of independence of qualitative properties of the geometry from the changes in size or shape as they become stabilized through stretching or twisting of continuous one-to-one transformations or elastic deformations (Kolarevic, 2000) as similar to what D'Arcy Thompson questioned in his transformations.

■

Training neuromorphic computing chips can become an issue of software solutions regarding **the potentials of artificial intelligence** that have not been fully exploited yet for intuitive computations. On the side of software models that are truly alternative to the existing classical models, the rise of **Intel's Parallel Studio XE** solution, once again, should be presented here as one groundbreaking development in the advancement of artificial intelligence models with their accompanying script-based solutions. More openly, Intel's proposal can be regarded as a platform that is able to generate its alternative forms of scripts and syntactical possibilities by learning and generating novel iterations and offering the best optimized solutions, just revealing the actual potentials of artificial intelligence. From Norbert Wiener's cybernetics (1948) (Philip et al., 2018) to the molecular computation and biological synthesis (of even cloning and entanglement in nature regarding the subjectivity and artificial intelligence), Philip defines such similar levels of development at the second-order cybernetics that enable conversation (Philip et al. 2018).

Towards the new possibilities of universal machine thinking (not universal but holistically probabilistic), it is possible to give answers to the challenge of multiplicity to Wiener's question even by the development of quantum computers and even by the software platforms of Parallel Studio for the artificial intelligence in scripting. In the execution of the complex attractors of Life and their architectural designation, Intel Parallel Studio XE can be set together with the platforms of Software Developers and Compilers like Visual Studio. So, it is possible to argue that Intel's recent moves signify their role of being a game-changer, providing the recent software development platform which injects the possibility of intelligent alternation and decision-making among the various coding alternatives. Their proposals enable not only the efficient way of coding for a certain goal but also plot and map the possible ways for further behavioral pattern of code assemblies. In other words, such developments can be seen as the possibility of regarding artificial intelligence and deep learning within the syntax of the computational logic. This can also be regarded as **a means for the way of universal thinking** to provide the learning grounds among the scripts of axiomatized truth and the attractors of possible alternatives out of the box of the rationality of the professional science. Additionally, in the way that the new interfaces provide the fringes of possibilities among the alternative scripts, the technology can be developed through new technology of parallel and probability computing. Similarly, the usage of Quantum hybridized information in AI, Q-layered hybrid, and active usage of short-term memories are essential to describe hybrid transfer models. Q-layered hybrid AI solutions can even enable to overcome breadth-first or depth-first search dilemmas in AI if there can be known 'Oracles' for solution space (Wichert, 2014) without much more breadth-first or depth-first searches.

■

Psychophysics, Sensory Evaluation & Computational Neuroscience: The analyses for human-artificial interaction in learning environments with the creative subject and artificial agencies range from psychophysics to neuroscience in relation to sensorial analysis. The subject's learning mechanism in space-time can be thoroughly evaluated in the rise of informational technologies lying between the energies of matter (through respective entropy) and elements of thought in motion. This part of the study, hence, remembers the rise of new technological developments such as neuromorphic computing chips with regard to the initial examples of smart spaces. The attempts and studies in contemporary architecture like *ADA Projec*t, for instance, still multiply the possibilities of action, creating the interspaces of matter and mind between the subject and the artificial (Arbib, 2012). The embellishment of the built environment can be rooted with the help of artificial intelligence and state-of-the-art technologies, having the ability to recognize performance-based and agent-oriented behavioral patterns and predictions for decision-making generating dynamically adaptive environments.

The distinctions between psychophysics, performative and appearance-based assessments enable us to distinguish the different sensorial reactions. In the development of artificial sensory environments, the dichotomy between Cartesian and topological spaces in detecting location, orientation, and agents' involved features can also be classified in a similar pattern. Although the dominant research field is based on visual stimuli and visual detection, the concerned inquiries are also relevant in motion-tracking analyses. Thus, the visual and non-visual sensory fields carry huge performative potentials to develop biologically inspired artificial information processing systems and mechanisms. The distinction between the conditioned or unconditioned environments with conditioned or irregular inputs can also be studied with the subject's forced or non-forced choices.

The parallel interest over mind and matter with the rise of modern science on motion theories can similarly be constructed upon the inquiries over the thermodynamic laws of moving agents and the research on information theories[125]. Gustav Theodor Fechner has pioneered, for instance, the emergence of **psychophysics** as a research field in his '*Elements of Psychophysics'* (1860; 1966). The research domain finds a place in between the research of mind and matter (Kingdom & Prins, 2016, p.1) in close relation to the understanding in Life sciences as being developed parallel and engaged to the principles of mechanics and the inert nature of psychology. Therefore,

[125] In the late 19th century, initially Ludwig Boltzmann dealt with the essential concepts of motion (Boltzmann, 1974) and the studies have been projected on the entropy-related algorithms that would be used for counting the data of the agents of knowledge transfer with certain energies as information. Further interests upon mind and matter relations such as Bergson's evolution and memory researches, or Russell and Whitehead's studies (Bergson, 1998; Whitehead & Russell, 1927-1963) on the close relationship between biology and physics can be glimpsed as parallel to the inquiries of Fechner as the pioneer of psychophysics. This has showed the greater importance of the professional knowledge scattered through many different fields of interests and inspired many scientists later such as von Neumann or Shannon as well in the emergence of the most primitive nature-inspired artificial neural mechanism and automaton systems.

psychophysics facilitates the rules of nature (of physics and mechanics) and enables to get the deep psychological behavior of the subject under the light of similar knowledge[126]. Apart from this inquiry, the usage of informational knowledge of entropy is evolved to computational neuroscience. 'Sensorial evaluation', as a different branch, has also shown further progress, ramified and multiplied from psychophysics as evolutionary progress in line with the informational theories.

The evolution from **psychophysics** to **sensory evaluations** and **computational neuroscience** also corresponds to transformed domains of similar attempts on the relation of matter and mind[127]. Psychophysics can be explained as a research field to find out the relation between the sensations of the external stimuli of objective realities, perception of those, and the responses given by the subject. **Sensory evaluation** of subjectivity, in another case, is a concern of subject-object relation that is just focusing on weak and strong interactions in specific energy fields. The data of actions are evaluated through the usage of entropy as the generation of highly directed information by the abstract rules of motion. On the performative aspects of the subject, psychophysical inquiry of subjectivity can be defined not only through the sensory evaluation (motion of info between senses and thought) but also by its subjective feedback, to get the degree of subjective responses, analysis of unconscious thought, and learned patterns. Accordingly, the associative memory map is an epistemological and practical itinerary from sensorial evaluation to consciousness between human-artificial interactions.

On the side of the **natural agent**, what makes subjectivity interesting can be the approximating weights of different representations that are displaced during the rehearsal. Beyond these, the parallel facilitation of an activity pattern across many

[126] The domain of flows of waves and particles with "strong and weak interactions" in the interplay of these actions also corresponds to the field of psychophysics (Ballif & Dibble, 1969) referring to the dualities of human-artificial in the connected action of subject and object. It is so momentous to detect the psychophysical relations of subject-object interaction in the literature of motion not only to discern the dynamics of flow of sensorial stimuli of external forces with certain interactions but also the corresponding responses of subjectivity under the influence of internal fluxes and dynamics. In the assumption of a continuum of spatiotemporal experiences; "Psychophysics is the study of the relationship between the energy in the environment and the response of the senses to that energy." (Lawless, 2014, p.1).

[127] The research field of psychophysics can initiate the debate of subjectivity online to the reality with sensorial mechanisms (Kingdom & Prins, 2016). Psychophysics can be seen as a chance to channelize the idea of subjectivity further from the studies of neurosciences, philosophical assumptions on the mind, matter, and memory as well as from flourishing studies on the novelties in physics and psychiatry; and cognitive sciences. These novelties also reveal new contradistinctions of the multiplicity of new reference systems of assessment.

nodes in a module, that cannot be stored in one single module (Hestenes, 1998), is a principle of nature of the brain, revealing associative learning in long-term memories. This explains the advantage of the brain against microprocessors and Subjectile versus Objectile. Thus, any kind of knowledge or a pattern of activity of one individual can be rehearsed from the different connections of a module but with a little variation of associations, which betokens for an evolution *per se*.

The concept of '**threshold'**, accordingly, is common to assess the behavioral and cognitive impacts that make the insights upon interactions more concrete. It can also be said that "An absolute threshold is a minimum energy that is detectable by the observer." (Lawless, 2014, p.2). Among the tasks of discrimination and preference, first, the described energies that are filtered with a threshold not only specify the aptitude of the agents in performative-based tasks but also enable to assess the degree of attention in sensorial mechanisms of biological creatures. One astute classification, for example, can be made among the 'performance' and 'appearance' of the experiments ranging from the stimulus to task, method, analysis, and the measure in the ordered steps (Kingdom & Prins, 2016, pp. 11-35). It depends on the threshold and the observer agent's response in reaction to the given stimuli. Respectively, it can be said that visual stimuli of 'appearance' can be assessed with its brightness, color intensity, orientation, and hue of the colors.

Other features can also be read from the retinal fields' signaling activity, which is strong among the 'non-forced choice' of the agent and has a place in the classification of Type-2 reactions (Kingdom & Prins, 2016). One can also be asked, however, rather for his/her more subjective performance on the judgment of detecting the size of the objects as big or small. Similarly, any other inquiries can be answered with 'yes/no' responses, which can also be seen as an inquiry for fuzzy logic. The quantitatively assessable thresholds of 'non-forced choices', together with the 'forced choices', create Type-1 reactions that subsume for the performance-based tasks (Kingdom & Prins, 2016)[128]. They are significant not only to understand the subjective bias, that

[128] It is even possible to note here the existence of supra-threshold (Kingdom & Prins, 2016) against the thresholding experiments in the fields of psychophysics. Nevertheless, it is so important to understand the associative relation of forced and non-forced choices of agents to distinguish the concern of 'humanized technology' in the analysis of sensorial stimuli. Yes/no responses, then, are so precious to get a psychological response as well as an interface between the energies of matter flow and the sensorial evaluation of those energies,

can be classified as ideology in this study, but also their inner connections with the non-forced choices, as a desire, that can be assessed objectively. Non-forced choices, surprisingly, can also suffer from internal inhibitions (or biases) as a more intimate defect or difference.

In the choice of one individual, inhibitory and excitatory balance also becomes important either in value-based studies of decision-making or in temporally discrete value-based decision-making. It also outlines general studies on conditioned and unconditioned responses via strong and weak interactions. It may also be helpful to find common features as well as distinctions between the visual and non-visual data in relation to sensing and learning in spatiotemporal experiences; even to find a distinction between Cartesian and topological approaches and subject's decision-making in motion together with artificial information processing. Some of the experiments of biological agents within the conditioned or unconditioned sensory stimuli give light to learning and knowledge. The conditions that appeared to be recognized are subjected to a certain threshold to be detected by a specific agent in the interplay between the subject and its environmental forces through the chemical reactions of subjects. It can be relevant to remind here that even in the biological mechanisms of sensing and thinking, the minor threshold differences, undermined or not in these strong and weak interactions, could be consequential. These intricacies can play a mysterious role in figuring out the subliminal stimuli in evolutionary progress and alteration, ending up with surprising results or unexplained and uncertain subjective behavior.

Even the difference between the performance-based and appearance-based assessments would be helpful to remember that the different reference systems of evaluation in the territorialization of knowledge are facilitated and processed through different channels and by the agents of judgment. The performance-based assessment, in this respect, is crucial to figure out the relativity of subjectivity, its fuzziness, the conditioned stimuli, and responses that are territorialized in the lesions of the judicial agent. There can be given some cognitive examples, on the other hand, to determine

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external to subjective activity. To tell apart the deviation from a standard response of quantitative assessment as Z-scoring (Lawless, 2014), the Type-1 responses of the agent are so substantial.

the nature-derived scientific concepts on the sensory evaluation of perception. These statements also point out the significance of the observer in the degree of the weak interactions of the subject. These call for the significant concerns of psychophysics to deal with attention levels through the threshold values. To build up the existing discussion from the nature of matter to the interplay of subject-object, it is also possible to relate the essence of motion of energies in spatiotemporal experiences.

■

Cognitive Agenda for Motion & Moving Agents in Space: The unified whole of the central nervous system and the peripheral-sensorial functional system of the body is an evolutionary research question in the analysis of 'moving agents' (Ballard, 2015, pp. 41-80). The studies on the reactions of the unified central nervous system in relation to moving objects on the act of moving agents are also hot topics in cognitive, theoretical, and computational neuroscience and in the branches of medicine. With some line of thought from psychophysics, some neuroscientific researches put light on the central neural activity of creatures as: "Brain activity in the medial prefrontal cortex and striatum clearly reveals the idiosyncratic values people place on goods, actions, or rewards." (Glimcher, 2014, p.687).

The configured space and the temporality of action/selection are based rudimentarily on the maze experiments on animals (and humans), called as 'maze learning' (Hebb, 1949), enriched with different reference systems of assessment of sensorial activity and behavioral analysis. Comparative reasoning between the visual and non-visual sensorial inputs, their rehearsal, and reasoning in uncertain conditions are the essentials of the experiment to testify and make insights upon the learned response, so-called performative-based and appearance-based tasks in motion learning. One can even argue to sense a topological environment by non-visual, tactile senses, and it is actually more natural than a rational approach for its continuity in experience. It can be defended that a tactile experience is far more accurate in interaction with a topological geometry. It may not be possible, however, to construct such spaces of experiences only with the data of tactile senses. Since the visual field of objects are somehow virtual and processed through neural connections in the brain, the depth of imagination as the distant relationship between the moment-A and moment-B can be strongly reinforced with visual sensations. This not only declares a possibility of exchangeable sensorial data and agents for the same geometrical axioms but also reveals the potentials of imagination in psychophysics to assess the depth and momentary distance, or duration, in the sensorial assessment.

Objects of visual recognition, for instance, are subjected to the requirement of light to be detected by biological creatures. It would not be wrong to classify the studies over motion detection of thinking and information processing apparatuses as ‘natural’ and ‘artificial’. Special features of photoreceptors in retinal receptive fields are the receivers of sensorial mechanisms of vision. The light intensity and the darkness of objects are detected with their shape, though their color, and the saturation, recognized with different types of cells in the retina (Dayan & Abbott, 2005; Zeki, 2009). What is significant in the visual recognition mechanisms of biological creatures is the inspiring force of innovative and artificial information technologies. It is accepted that the light-sensing features of receptive cells in retinal fields process the orientation and spatiotemporal states as transmitting the input through *Lateral Geniculate Nucleus* (LGN) in the limbic system that is transferred to the visual cortex, to V1 cells (Dayan & Abbott, 2005). The process is far more complex than the intended explanation here, so what is significant to describe is how the interplay of object-subject interactions is realized. Since the objects are detected with their particular features under light, they are also transmitted with electrochemical reactions in the brain and through sensorial mechanisms of the biological agents. This means that they have a certain mass of a particle and features, either radiated in waves or in different levels of energy fields of substances that are carried through sophisticated biological channels and tissues. The features of particles in the agents, that are observed; and the representational weight which is carried through the observing agent create a gap of virtuality between the sensorial evaluation and psychophysics. They also led us to understand the differences and common points of the physical world and biological mechanisms, yet correspond to each other, in the same spatiotemporal experience that is shared.

■

The function of the forebrain between the higher degree complexity of cortical regions of the central nervous system and the sensory-motor system through the spinal cord regulates not only the life activities but also regulates the interconnection of external forces with the internal logic of mind. It achieves such regulations by programming itself on cortex-basal ganglia-thalamus loop, connected to the spinal cord, throughout the inputs of kinematics (motion, action of movements in sequences) (Squire, 2008).

The formation and rehearsal of memories from learning, however, is still a bit mysterious. It makes yet possible to analyze the knowledge acquisition in terms of the subject's inner mechanisms that are focused around the theme of territorialization. Respectively, the acquisition and usage of knowledge would be conceptualized again under the general terms of energy, motion, subjectivity, and space-time continuum under the principles of matter. The connection between the long-term memory of the cortex and the immediate input of sensorial activities, for instance, is first taken over as a task again by the forebrain. Even the visual fixation of eyes due to the result of retinal disparity (Dayan & Abbott, p. 15) in the successive inputs of action is dependent on the regulation through the forebrain. The resolution of an image in retinal disparity is also dependent on the visual cortical activity of V1 cells to retrieve the pre-representation of the image data to resolve the image distance that in the attention mechanism of the continuous data of motion basal ganglia should also play a considerable associative role (Zhaoping, May, & Koene, 2009). The basal ganglia in the forebrain are consequential in the regulation of body and eye movements of the gaze in the succession of the continuous data. This phenomenon is a part of the attention mechanism as well as an interconnection between the cortical activity and the sensorial system. Thus, basal ganglia have a critical role in the execution of motion programmed by the agent. In general, it can be said that basal ganglia conduct the selection and the generation of sequences of activities. They can be motor movements or higher-degree programmed mental activities (Ballard, 2015), including the fixation of gaze in the successive activities of eye movement. Just to complete the topic of the corporate formation of programming or perceiving motion activities, hippocampus also plays a critical role in the creation of the structures of that programming as part of learning and retrieval activity (Ballard, 2015). Cerebellum adapts the system, and thalamus conducts the input and output to the forebrain (Ballard, 2015), yet the hypothalamus always plays the critical role of regulation of five drives in the projection of life activities in these programming.

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When searching for the artificial knowledge grounds for moving agents within the space, the seminal book of '***The Organization of Behavior***' written by Hebb in 1949 is strongly suggested. Concerning the stages from primary learning to maturity of adult learning, the rationale behind sensorial and cortical mechanisms are diagnosed under a theoretical framework (Hebb, 1949). The manifold of multiple sensing is correlated to the relations of recognition and thought in principles of associative learning and decision-making processes. This can be exemplified with the case of the psychophysics of appearance-based evaluations as well as the logical iteration of the agent during the experiment as performative-based insights. The basic instinct mechanisms of fight or flight psychology of emotional disturbances (Hebb, 1949; 1958) are also important here besides the external inhibition of distraction or/and internal reasoning mechanisms. These learned inhibitory mechanisms are further hypothesized as the vestiges of discrimination of cognitive bias in line with our reasoning practices, in different degrees.

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The rules of neural networks for the artificial layers of long-short term memory models are designed according to the principles of motion in electromagnetic fields and their time-related flow as similar to brain mechanism (LSTM, MATLAB, 2021). LSTM-layers give a clearance about the string connection of immediacies and perceptual actions in sequences in short-term memory together with the durations of features and learned actions that are pooled (memorized). A LSTM-layer learns long-term dependencies between time steps in time-series and sequence data. The layer performs additive interactions, which can help improve gradient flow over long sequences during training. The interconnections via LSTM layers are eligible to be designated according to the developed rules of artificial intelligence.

■

Tactile and Visual senses in motion planning: To develop motion planning of robotic arms in the book '*Sensing, Intelligence and Motion. How Robots and Humans Move in an Unstructured World*' (Lumelsky, 2006), experiments reveal that visual data help much and far more efficiently than the non-visual ones to decide where to go. What makes non-visual and especially tactile sensorial data so important is concomitant with its humanized (or biological) nature. Tactile senses provide ubiquitous data to control its environmental change. From the experiments comparing robots and humans in the same labyrinth to find the path, it can be concluded that in the existence of visual data, robots perform far more efficiently than humans' while evaluating the data on a 2D Cartesian coordinate system (Lumelsky, 2006, p.177). Tactile senses, on the other hand, are directly pertinent to their continuous connectivity with the environment that makes biological agents more adapted to their ecology. EEG (electroencephalography) diagnosis of humans during dreaming also shows that only tactile sensing continues and contributes much to the learning and memory of the subject (Hebb, 1949; Park, 1998) while sleeping. This fact cannot be completely simulated with silicon mechanisms of 'ON' and 'OFF' (or basic logic gates like Boolean) gates. This fact can also clarify the construction of the learning activity of humans and its performance that is closer to microprocessors with far faster channels of electromagnetic circuits and capacities. It is the continued strong and weak interactions through the somatic and sensory-motor activities that are accompanied by the cortical activity conducted in a parallel process. The mystery of the human brain is directly involved with this reality that doing a similar task in comparison with a robot with far faster microprocessors and microcontrollers can be explained in the continuum of chemico-electrical reactions. From the experiments, it is also proven that without visual data and within an unconditioned environment of uncertainties, the human agent performs far better than robots in the existence of the tactile sense (Lumelsky, 2006). Analyzing the profound meaning of subjectivity and the self in the existence of flowing things, objects, and perceptual qualities, Cache also signifies the importance of the tactile sense in the realization of the thermodynamic existence of the self. Beyond the illusory capacities of our vision, the existence of 'associative' tactile sense actually supports our consciousness in the existence of multisensory mechanisms.

> "From a purely sensorimotor point of view, however, truth and error will be distributed on either side of the reflective plane according to our tactile control. In this second view, our body reassures itself as it finds a resistance with respect to which it senses its own reactive powers. What we take to be our vision is permeated by touch. But then our touch is but one part of the

> sensorimotor apparatus thanks to which we grasp things such as objects: by maximizing our actions and reactions. In fact, we rather mistrust those optical images that escape us and whose effects are beyond our reach. As if we were unable to see, we insist on placing the truth at the extremities of our limbs; but what is wrong with a vision that attaches itself to untouchable objects? In these audiovisual times, we may not live up to our eyes and may entirely miss the optical experience that Bergson took as being at the origin of the soul in primitive ways of thinking. For our reflection in a mirror would seem to invite us to remove the top layer of our skin from our bodies." (Cache, 1995).

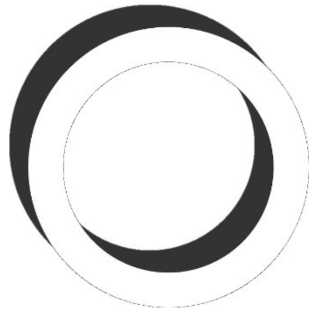
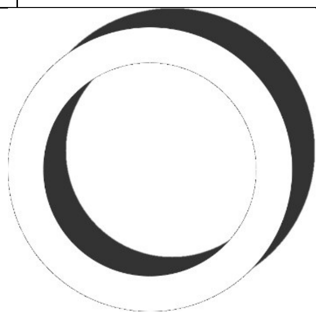
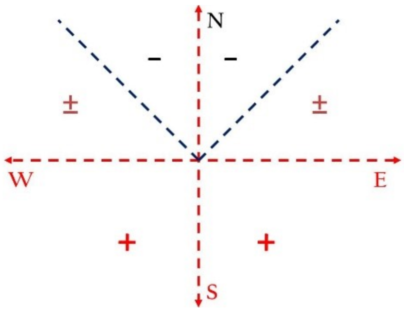
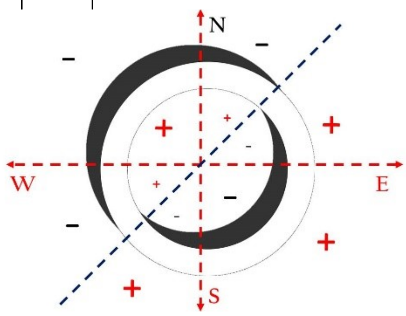
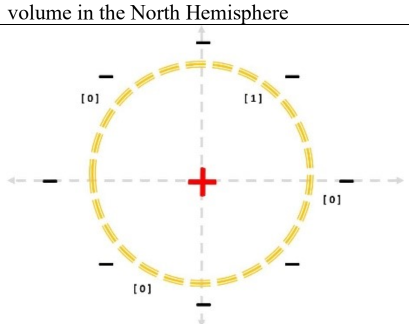
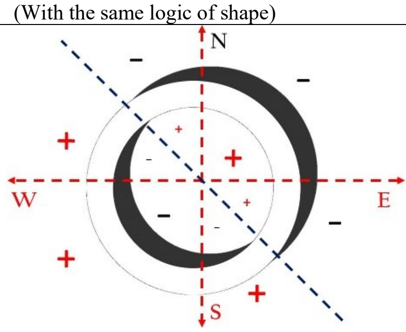
The rehearsal of the learning activity, as a remembrance, in the said pattern is decided whether by the long term or short-term memory; and also depended on the type of learning. To catch the energetic fields of change and difference between the weights (just from the second rule of mechanics) that carry information in its connection; the knowledge generation and its rehearsal are depended upon the input and output assessment of stimuli and the sensorial activity as well as the configuration of substrates with derived information in relation with each other. The rehearsal for the feedback mechanisms from different cortical regions depends on the activity of learning and the type of stimuli that is drawing the fundamentals of associative learning (Hestenes, 1998). The relative region of feedback in the central neural mechanisms decides on the performance of remembrance, its duration, interrelated representations, and the strong and weak interactions (Hestenes, 1998).

■

Exemplar case for the Problemata on Multi-agencies: The case of Apple Park still challenges a dispersal and displacement with a suburbanized environment. The urbanization of certain regions around Palo Alto can be transformed into the hubs of interaction and walkways around. For the similar scenarios of the new research or office park developments such as the Research Triangle, the ideologically critical point is to generate certain hybridized socio-economic habitats that can only reinforce the territorialization of deterritorialization. This can, then, again only be achieved with the desired territorialization either through walkways, relaxation areas, or with the insertion of intensified urban growth of living and consumption areas around the immediate surroundings or with both. The strong boundary between the territorialization of Apple Park at the inner side generates contrasts with the outer environment pushing for more displacement, a deterritorialization. It is here to simulate the initial stages of exchange of sensorial and logical iterations on the Apple

Park environment. According to this, first, the non-designer sends sensorial data of his/her impression related to the sun conditions to the designer (Table C1).

Table C.1. Simulating multi-agent design problems

			
i1	input_N.-D. Note: Apple Park's sun-shade from the top view at the dawn	d1	D. Analysis: Abstract shape of the building with its shape at the dawn
			
i2	input_N.-D. Note: Apple Park's sun-shade from the top view at dusk	d2	D. Analysis: Abstract shape of the building with its shape at the dusk
			
d3	D. Rehearsal: Usual sun condition for a cubic volume in the North Hemisphere	d5	D. Analysis: The sun-condition notation at dawn (With the same logic of shape)
			
d4	D. Analysis: The architectural notation with respect to its geometry/shape (The building creates high tension between the inside and outside)	d6	D. Analysis: The sun-condition notation at dusk (With the same logic of shape)

Then, the designer generates a series of critical iterations not only grounded upon his/her own culture of practicing (from the pool of memories) but also some uncommon logical iterations over the sun condition, as well as its architectural form and configuration (Table C.1). Respectively some hybridized solutions among the mainstream and alternative approaches in the field of architecture, from the pool of architecture and geometry, can be offered in the very first loop of the described interactions, which would be the first feedback for the non-designer as well, in the phases of communication for '*entangled connections*'. So, even a newly generated existing pool of sensorial environments can be processed in these feedbacks. It is, then, also be possible to make some cross-exchanges among the solutions.

With the transformation of classical memory into hybridized layers of ideological and desire patterns of long-short term memories and circuits, artificial intelligence can take the advantage of selecting best probability for the optimal design of action sequences in such interactions. Since the selection process is always multiplied with the existence of multi-reference systems of distributed agents, the motivation, as well as the commutation among different agents, should be regularized by the collective conscience, which would be a part of the total energy function that should be considered within the same dynamics. The recent endeavor on Broad AI, as well as the intense focus on 'Modelling Behavior', in that regard, can be scrutinized under the similar concern over modeling/organizing the behavior among the creative and productive artificial and subject agents and their media.

■

Evolutionary algorithms: Evolutionary algorithms like $v_i(t + 1) = f^i(v_{i1}(t), \ldots, v_{iki}(t))$ (1) generate the growth pattern, that is based on the sequences of new genes, v_i, as nodes from a linear logic (Akutsu, 2016, p. 31). It is based on the evolutionary sequences generated through a list of Boolean functions looking for the existence of new genes. In the ever-changing population of multiplying cells, the defined nodes as $v_i's$ in this algorithm define the ultimate set of time-depended populations. In the existence of multiple states of spatiotemporal experience, such algorithms can also be exploited in the field of design and architecture in defining the set of the behavior of movements for further calculation of the challenge of measuring the action of movement. The algorithm can even be applied to the growth of area of architectural spaces with respect to the new time-depended states of locations that can be represented by $(t+1)$. Differential equations can also be used to follow the evolutionary changes of the ultimate states. The derivative of the defined algorithmic relations can be used to find out the time-depended parameters and be used even in the search for the optimal solution with either minimum or maximum points. According to the equation $\frac{dv_i(t)}{dt} = a_{i,0} + a_{i,1}v_1(t) + \cdots + a_{i,n}v_n(t)$ (2) (Akutsu, 2016), it is possible to find out the parameters, $a_{i,j}$'s, at the time-depended expressions as levels of genes, $v_{i,j}$, at time *t*, if and only if ai,j ≠ 0, which should be replaced by |ai,j| > δ for some positive constant δ, in practice. Another level is just to extract out the possible discrete states of time-depended expressions of genes that evolve the algorithm into a difference of differential equations $\frac{v_i(t+\Delta) - v_i(t)}{\Delta} = a_{i,0} + a_{i,1}v_1(t) + \cdots + a_{i,n}v_n(t)$ (3), where Δ is the unit time (period between two consecutive time steps) (Akutsu, 2016). This makes the linear regression possible via the sum of sequential states and further regularizations of that by the amendment of the error rate. It is crucial to remind here that much more complicated forms of logistic regression via nonlinear differential equations can be iterated basically as in $\frac{dv_i(t)}{dt} = a_i \prod_{j=1}^{n} v_j(\mathrm{t}) g^{i,j} - \beta_{\mathrm{i}} \prod_{j=1}^{n} v_j(\mathrm{t}) h^{i,j}$ (4) (Akutsu, 2016). The equation (4) represents a higher degree of expression of genes as well as the polynomial states of parameters that turn the linear equation into a logistic function, as exponentially changing. The gene expressions are defined according to the functional parameters of *h,* represented with the parametric coefficient of β_i of the error function which are extracted from the g depended level of expressions with the parameter of a_i's.

Swarm Intelligence: SI (Swarm Intelligence) systems consist of a population of locally interacting simple agents or boids within their environment (Swarm intelligence, 2020). The inspiration often comes from nature and especially from biological systems (Swarm intelligence, 2020). The agents follow rudimentary rules. Even though there is no centralized control structure dictating how individual agents should behave according to a certain degree of randomness, interactions between such agents emerge as "intelligent" global behavior (Swarm intelligence, 2020). Examples in natural systems of SI include animal herding, ant colonies, bacterial growth, birds flocking, fish schooling, and microbial intelligence (Swarm intelligence, 2020). The application of swarm principles in robotics is called swarm robotics, while 'swarm intelligence' refers to the more general set of algorithms. 'Swarm prediction' has been used in the context of forecasting problems (Hassanien, Azar, Snasel, Kacprzyk, & Abawajy, 2015; Hassanien & Emary, 2016; Yang, 2015; Yang, Cui, Xiao, Gandomi & Karamanoğlu, 2013). The definition of Swarm Intelligence requires us to perpetually reevaluate the concepts of evolution and adaptation within the framework of dynamic logic systems and between agents and the environment with an ever-changing precession, which plays a crucial role in the artificial world, especially in the art of science and technology. Swarm intelligence also requires the pursuit of a continuous motion of the fourth dimension by focusing on a common goal with the behaviors of multiple agents as they interact in the third dimension with different relationship and identities (Bhattacharyya, S., & Dutta, P., 2015).

Self-assembly systems: Self-assembly systems work under the performative features, selected according to principles of materialistic sciences, which can still be organized with some algorithms (like DNA self-assembly by RNA GA or EA) through self-assembling robotics for material search and carriage.

> "Self-assembly—a governing principle by which materials form—is the autonomous organization of matter into ordered arrangements. It is typically associated with thermodynamic equilibrium, the organized structures being characterized by a minimum in the system's free energy, although this definition is too broad. Self-assembling processes are ubiquitous in nature, ranging, for example, from the opalescent inner surface of the abalone shell to the internal compartments of a living cell… Self-assembly is also common to many dynamic, multicomponent systems, from smart materials and self-healing structures to netted sensors and computer networks. In the world of biology, living cells self-assemble, and understanding life will therefore require understanding self-assembly. The cell also offers countless examples of functional self-assembly that stimulate the design of non-living systems. Self-assembly reflects information coded (as shape, surface properties, charge, polarizability, magnetic dipole, mass, etc.) in individual components; these characters determine the interaction among them. The design of building blocks that organize themselves into desired structure and functions is the key to applications of self-assembly. Much of materials science and soft condensed-matter physics in the past century involved the study of self-assembly of fundamental building blocks (typically atoms, molecules, macromolecules, and colloidal particles) into bulk thermodynamic phases. Today, the extent to which these building blocks can be engineered has undergone a quantum leap. Tailor-made, submicrometer particles will be the building blocks of a new generation of nanostructured materials with unique physical properties. These new building blocks will be the "atoms" and "molecules" of tomorrow's materials, self-assembling into novel structures made possible solely by their unique design" (Huang, Yan, 2016).

Evaluating Creative Crowdsourcing with Fuzzy Sets/Systems & AI: The population-related agencies of collective action can be better internalized within the further development of customized and hybridized synthetic solutions. It may be better to visualize the 'emergence' of the population as multi-dimensional data as revealed in Table C.3. The table can be interpreted with a time-based rate of change in the elements' selected features as in Table C.2 that would decide on the identity of things in the long term as a part of the duration and evolution of things. The 3D vectors' representational physical force fields, or movement, to come up with unit vectors, to understand the behavior of particle with its identity (of mass, feature), can be analyzed through time-derivative iterations. This reveals the immediate directionality of the physical force, volatilizing the processes towards evolution (Zak, 2011).

Table C.2. Comparative performance analysis of image recognition and object/feature extraction by Genetic algorithms (GA) and Neuro-Fuzzy algorithms (Neto, Meyer, Jones, & Surkan, 2003)

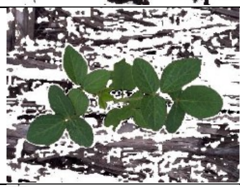
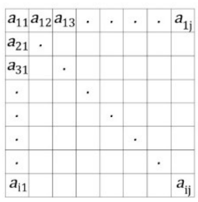
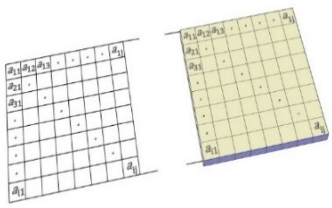
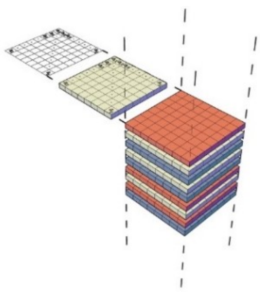
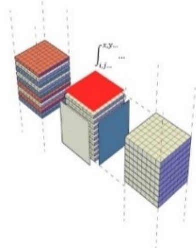
	a. Image (Data)	b. Neuro-fuzzy learning	c. Neuro-fuzzy learning + Genetic algorithms
1			
2			
3			

Table C.3. Visual representation of computations (drawn by the author)

			
(1)	(2)	(3)	(4)

As a return to the simpler version of computing actions and relations, one single feature for all agents in the population creates one feature-based layer of data (as in neural networks that can run deep learning algorithms). This data can be multiplied according to the number of feature-based parameters (which can be the color of flowers, the height of buildings, the weight of vehicles or people) as shown in Table C.3.3. Once many data (as three-dimensional cubes in the tables) can be collected for a certain defined population, data distribution can optimize the feature-based parameters according to particular training and test sets (Table C.3.4).

These topologies (cells/arrays of higher-dimensional data in 3D or 4D) of motion-based interactions can also be re-parametrized yet again by evolutionary algorithms. Accordingly, it becomes possible to find out directly corresponding informational/assessment bases in the intrinsic nature of things. It is here to manifest the syntactic models departing from the dichotomy in the second (digital) turn of the creative evolution in architecture. Concerning the aim/purpose in the knowledge generation, pragmatic methods in progress still potentiate to get concrete results in the expected search domains like duration and motion.

The conditions that appear in the cases of swarm intelligence may change in population or location, or there can be a rate of change in the feature-based properties in evolution to be detected in the research of bioinformatics; and to be processed by genetic or evolutionary algorithms. Furthermore, new memberships or even other kinds of agencies can further be described in the evolution of the population with feature-based parametric relations. In Table C.3, the population array can be seen as a matrix that can be organized in many different ways. Having $i*j$ dimensions, number of i rows and j columns can also be used for simpler categorization and interrelation among the rows and columns, or they can also be clustered according to the discrete as well as continuous-time series as well as linear or non-linear functions (1), (2), (3), (4). Fuzzy logic, accordingly, constitutes mapping an input space to an output space with respect to the list of preferences, subjective experiments, pre-defined and categorized modalities, and their sequential causalities and statements. In the practical usage of fuzzy logic, fuzzy sets encompass the clauses and causalities among those statements by organizing them under logical statements such as AND, OR, NOT

(Keller, Liu, Fogel, 2016). The integration of artificial neural networks with neuro-fuzzy learning systems and adaptive neuro-fuzzy inference systems and networks can be found much more complex in the training of the statements, preferences, and experiences as informational data that are localized. There are practical searches over the usage of ‘Adaptive neuroimage processing’ as well as much more subjective researches such as language-based meaning classifications. Preference classification of customers/people; and finding cross-correlations graphical outputs of feature-based data sets are among the tasks that neuro-fuzzy systems take over the great responsibility in the integration with other artificial neural networks. Therefore, how fuzzy logic operates basically in the flow of informational circuits can be explained as using the logical gates of AND, OR, and NOT. Rather than directly assigning reductionist numerical values or constraints to statements and conditions, the circuits are mapped with respect to the interrelated logic of those statements and arguments according to their cross-relational modalities with respect to those logical structures. Accordingly, neuro-fuzzy systems even can be used in ‘Chaotic time-series prediction (that is, integrating discrete and continuous time-series)’, requiring much more complex arguments.

Fuzzy systems can be used as self-efficient artificially-intelligent decision-making systems just selecting the optimized solution on the organization of data structures, in the down-sampling of crowdsourced data as well as the prediction of the outcome that can strongly correspond to the test data of the logic that are already defined with their degree of memberships and modalities. Shortly, the necessity of informational transformations of biological & emergent dynamics in relation to the fuzzy sets of subjectivity, as in the usage of fuzzy sets for object recognition, reallocates the local dynamics (of subjectivity) into the informational knowledge.

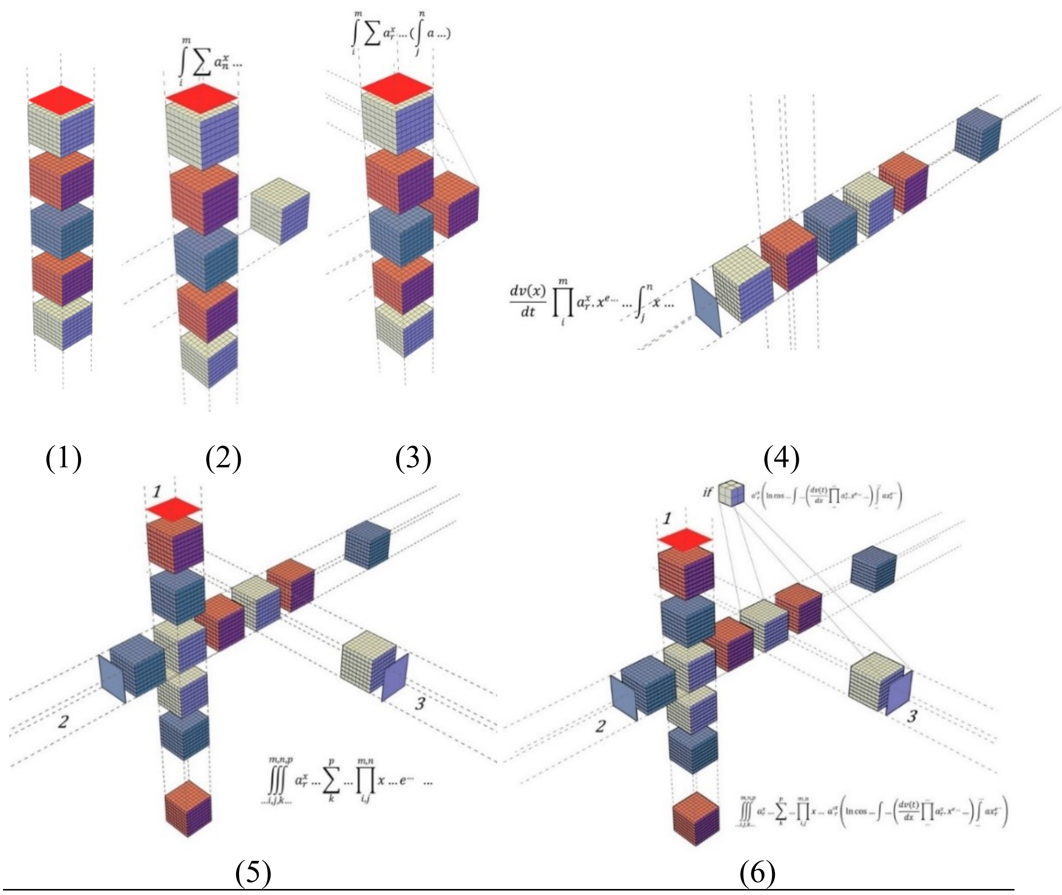
■

Descriptions for Transactions in Creative Crowdsourcing: The generative modalities/algorithms can enable to get one ‘winner’ feature (just as in finding the winner neuron among the bundle of multiple fired neurons, as an evolutionary algorithm between the new and old), or corresponding parameters of action as represented in Table C.4. This can also be seen as a task of convolution. **Convolution**

can be defined as calculations just like considering 'the shifts and differences between variables of different functions with real values (conv, 2018-2020). Considering the dot product of vectors R^n that are made of the spatial variable of x and frequency of ε as $R^n = x.\varepsilon = x_1.\varepsilon_1 + x_2.\varepsilon_2 + \cdots + x_n.\varepsilon_n$, the functions with variables defined over the series of those dot products can be calculated through convolution, which can also be considered with shifted or stretched periods. The simpler version of convolution can be analyzed on two functions with their variables as $(f * g)(x) = \int_{R^n} f(x-y)g(y)dy$; and the increase in the number of data affect the algorithms as such when for example, n=2: $(f * g)(x_1, x_2) = \int_{-\infty}^{\infty}\int_{-\infty}^{\infty} f(x_1 - y_1, x_2 - y_2)g(x_1, x_2)dy_1dy_2$ (conv2, 2018-2020). As an additional note, MATLAB shares the multidimensional discrete convolutions via another way of handling the different lengths of two vectors u and v with a search algorithm as such: $w(k) = \sum_j u(j)v(k-j+1)$; and for discrete two-dimensional variables of A and B as $C(j,k) = \sum_p \sum_q A(p,q)B(j-p+1, k-p+1)$ (convn, 2018-2020) and for N-dimensional variables. Whereas it is suggested to work with learning algorithms by exploiting the given two variables with two dimensional $C(j_1, j_2, \ldots j_n) = \sum_{k_1}\sum_{k_2} \ldots \sum_{k_n} A(k_1, k_2, \ldots k_n)B(j_1 - k_1, j_2 - k_2, \ldots j_n - k_n)$ (convn, 2018-2020).

Table C.4.1, C.4.2 & C.4.3 represent the discrete-time periods that are also dependent on the long-term rehearsal of features in action-based variations as well as conditions of complex and creative crowdsourcing. The tables are in the logical step of depicting the accumulation of time-based changes of property relations and the derived selection of some features from many of the data, as given in Table C.4.2. Table C.4.3 reveals the optimization of a larger range of data with the rate of change in time with respect to that of scrutinized features so that consistent observations on larger data sets (sensible duration of things that are emerged or appeared as distinct) can be distinguished. Table C.4.4 shows a spatiotemporal evolution as looking up over the change in the data sequences in continuous time-series. With respect to this, the increase in the data by the multiplicity of new feature-based parameters of the agents (or population; or both) can be visualized in Table C.4.1. Accordingly, there can be found some algorithms to find out common distribution models among various data either for finding a population-based definition or for extracting out the feature-based parameters for a certain population (Table C.4.2). It is also possible to follow a multi-dimensional complexity of change that should consider both. This, respectively, requires further selection of classifiers either for feature parameters or population selection to find out special data that link all variations in the algorithms, as represented in Table C.4.3.

Table C.4. Detailed Computations in Chapter 4 (drawn by the author)

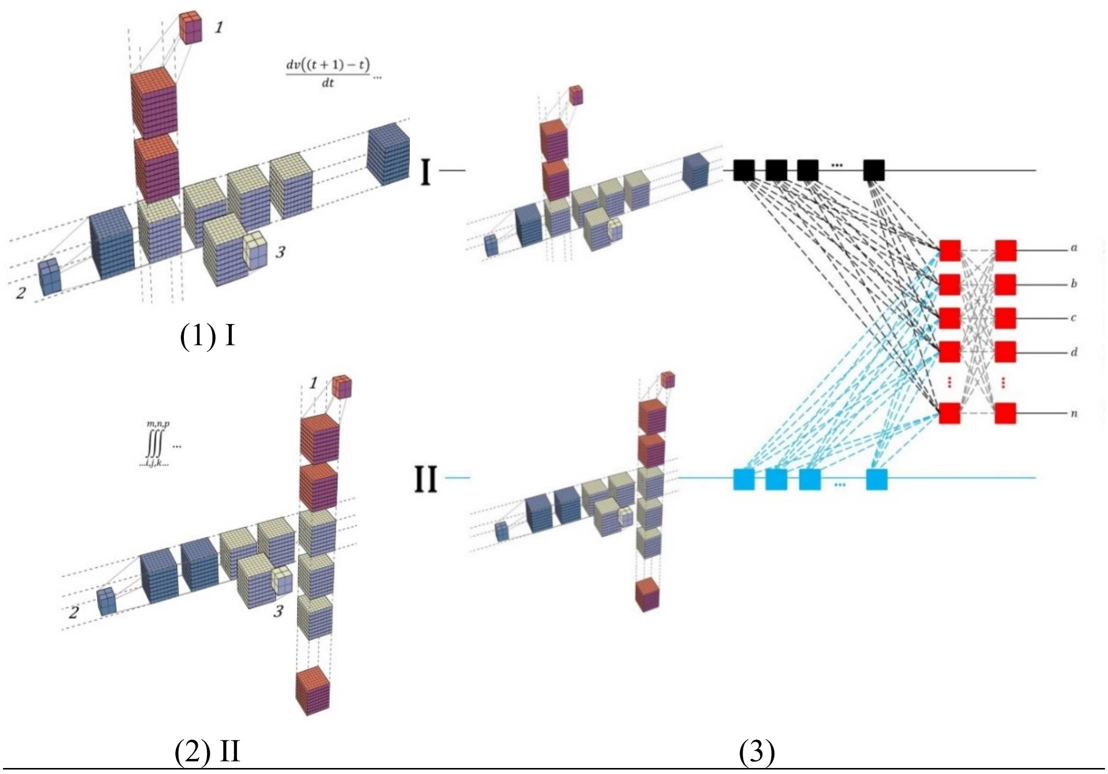


However, Table C.4.4 looks for a spatiotemporal action (of motion) aside from constantly evolving other factors as control parameters. In that case, evolution can be described as continuous. Yet, much more data connected to the external forces are necessary regarding the topological complexities and nonlinearities within. That also requires the exploitation of short-term memories for the efficient recognition of environmental factors and forces to be searched and optimized through other kinds of algorithms (Table C.4.4). Motion-based evolutionary changes in the same population-based data can be tracked by moving architectural design agencies with active

Augmented Reality media. Thus, the change or optimization of feature-based population data (as well as the discrete attractor/repeller points in the nonlinear motion action) can still be followed to be internally computed in algorithmic relations. It is here to remind that collecting data and making inferences by architectural agents require higher degree organization and arrays of higher dimensional matrices as topologies beyond three and even four dimensions (Table C.4.6).

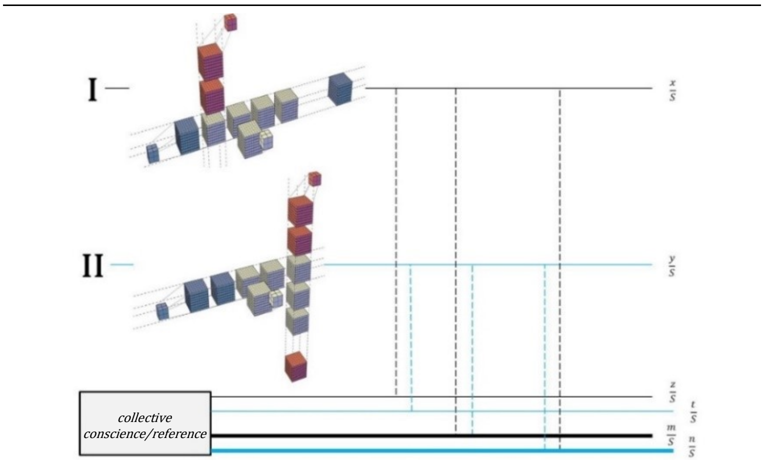
As a part of swarm intelligence set-up, there can be found separate teams of missions that can either be shuffled or re-organized flexibly. There should be the agencies of evolutionary spatiotemporal experience, for example, for much-more continuous time-related activity, having the ability to move ubiquitously. Such form of collectivity instead utilizes the abstract rules of motion; and looks for certain action relations in motion (I) as in Table C.5.1.

Table C.5. Organization of Creative Crowdsourcing Systems for Decision-making (drawn by the author)



Alternatively, other agents can cluster around other sub-groups as teams to focus on the generation of feature-based data with the help of bioinformatics (Table C.5.2) as they may also catch the moving agents in time. It can be seen as a task not only for spatiotemporal memories (pooling) and feature-localization but also for action and feature recognition. The agencies of distributive systems can still control the creative togetherness of those agents of architecture to check for the hybridized multiplication of 'cross-fertilization' techniques of multiple data; and for possible cross-correlational outcomes of an action to come up with novel solutions in decision-making models represented in Table C.5.3 & Table C.6.

Table C.6. Decision-making in creative crowdsourcing for advanced many-body systems (drawn by the author)



D. APPENDIX FOR CHAPTER 5

Quantum mechanics essentially dwell on the basic nature of things in their mechanical dynamics not to be seen as linearly moving, but as particles that instantly radiate, oscillate, and to be recognized by their frequency in the energy spectrum. The phenomena of particle-wave interactions, hence, are to be measured through quantum energy fields and functions. This fundamental principle also reminds us of the necessary scientific principle of **particle-wave duality** (but also their interaction) and even **gauge-gravity duality** (Ammon, 2015) that the scientific discoveries have finally enabled the advancement in the new computational technologies.

▪

Quantum Information Theory and Algorithms: There are problematic intricacies that classical science and computation, including Shannon's Theory of Information, cannot solve. Thus, it is to explore **quantum information theory** from its basics that have substantial contact with the physical theories of quantum fields and their relation with information that exist in space-time. Yet, they are transformed into an abstract logic of wave functions by the pioneering studies of Dirac's equations. The applied principles of quantum theory can be explained through some basic concepts as in need of explanation like 'indeterminism', which points out the roots of quantum theory that only works for probabilities (Wilde, 2013). Another principle is '**interference'** that explains the interactions between the waves with their directionalities that either produce stronger waves or cancel out each other. The experiments that are acquired from the double-slit experiment, for example, show the intricate feature of interference because the atomic particles such as electrons also exhibit wave-like features explaining the wave-particle duality (Wilde, 2013). On the other side, it should not be forgotten that most of the quantum theories and mechanics rely on the pure isolated experiments that extract the noise of the environment even if the next challenge of quantum perspective of Life awaits to be considered with complex environmental coefficients. Another concept is the '**uncertainty**' that it may be enough to tell the nature of the measurement of the single-particle that it has two complementary variables: Its position and its momentum (or velocity), as it is impossible to know both precisely by classical means. In quantum theory, we can only know what we measure, and "we can only know the position of a particle after performing a precise measurement that determines it. If we follow with a precise measurement of its momentum, we lose all information about the position of the particle after learning its momentum" (Wilde, 2013). Similar to Peter Shor explains why **universal circuits** are important as hiding the two variables discretely without losing information, it is a problem of uncertainty as well as a way to compute the discrete co-existence of states that are hard to measure by classical means of computation and information systems. Thus, Quantum information systems can keep the informational knowledge of different parties, systems, states against the challenge of uncertainty in measuring 'ground' and 'excited' states; or relative properties and movements; emergence-based parameters and motion-based parameters.

■

The evolution of quantum states can be described through the operations of "rotational evolutions". Thus, the measurement of quantum states infers to the retrieval of classical information as an evolution that the quantum systems undergo. Throughout certain operators, such as the Hermitian operator, it is possible to learn the position or momentum of a particle.

Fourier Transform (Rieffel & Polak, 2011; Adams et al., 2013; Adams, 2014) is a genuine way to translate complex energy functions into the corresponding frequency functions (in quantum fields) to overcome the classical numerical methods. From the fourth chapter, for instance, the abstract formalisms of creative crowdsourcing can be transformed by Fourier series. Fourier transform algorithm can be given as $\mathcal{F}f(\alpha_1, \alpha_2, \dots \alpha_n) = \int_{R^n} e^{-2\pi i(x_1\alpha_1 + x_2\alpha_2 + \cdots + x_n\alpha_n)} f(x_1, x_2, \dots, x_n) dx_1 \dots x_n$. (Adams, 2014). Fourier equations do attempt to get an ordered data with a periodic function to control the way that the data change; or do get a sector of classified data that can be distinct within the given set and can have some fuzziness. In his lecture, Prof. Adams begins by summarizing the postulates of quantum mechanics. He also discusses the properties of the Schrödinger equation and methods of solving this equation[129].

■

The most intriguing and authentic concepts of quantum information theory are '**superposition**' and '**entanglement**'. Superposition corresponds to the linearity of combinatory quantum state with any other two allowable states as in the case of Schrödinger's wave equation. $\alpha\psi + \beta\phi$ is a coherent superposition of the two solutions if ψ and ϕ are both solutions of this equation. Superposition explains the quantum probability against the uncertainty by this equation. A particle, accordingly, can either "be in one location and another" (Wilde, 2013) at the same time.

'Quantum entanglement' makes the feature of particles and waves truly "quantum". Entanglement is "the strong quantum correlations that two or more quantum particles can possess". Another explanation can be put as the intricate emergence of particles, elements of space-time interactions that co-exist in discrete and yet possible networked formations. It explains the possible symmetry or similar modality of angular relations in the "Bloch sphere". Thus, the particles can co-exist and carry the coherent information whether if they are discrete or networked through complex and intricate interactions. Thus, it is hard to define the nature of entanglement in classical correlations. Even though Bell tried to find out unique cases for entanglement of inequality, there are also studies on EPR particles (derived from the 'local hidden-variable theory' of Einstein, Podolski, and Rosen upon the intricate nature of uncertainty through entanglement) that later violate the Bell's inequality in the experiments of quantum entanglement (Wilde, 2013, p. 10).

■

In quantum information theory, one 'qubit' by the convention of 'Dirac notation' can be represented as 0, 1, 00, 01, 10, 11, …., ↑x, ↓x, ↑y, ↑z, which transmit the information of the two-level quantum system of the states of 'the spin of the electron', 'the polarization of a photon', or 'an atom with a ground and excited state' including the vectorial information (Wilde, 2013). The fundamental bases of the flipped coin

[129] See also (Shor & Chuang, 2018a; 2018b; 2018c; Nielsen & Chuang, 2010).

express the states of the probability of AI. The action that an artificial light source is switched either on or off can also be represented by binary numbers of "1" or "0". Thus, each condition showing the 'head' or 'tails', or the case of light is 'switch on' or 'off' can be transmitted as 'one-bit information'.

From the development of BB84 notation to compute things in a universal circuit, the notation of two classical bits as 'cbit'(s), however, can be expressed by one 'qubit' in the form of "ket"s with respect to the internal change among those bits as such with a vector representation: $|0\rangle \equiv \begin{bmatrix} 1 \\ 0 \end{bmatrix}$, $|1\rangle \equiv \begin{bmatrix} 0 \\ 1 \end{bmatrix}$ (Wilde, 2013), just like the transitive phases from ON to OFF, or OFF to ON. Additionally, the linearity of the Schrödinger equation that expresses the evolution of quantum systems can be constructed as $\alpha|0\rangle + \beta|1\rangle$. As qubits give information about the vectorial forces of quantum systems with their directionality on x, y, z axes, it is crucial to understand the previously discussed dynamics of Hilbert Space and the models of 'spherical geometries' beyond Cartesian geometry. 'Bloch sphere' "gives a valuable way to visualize a qubit". In that convention, "bra" notation has the representation of row vector such as $\langle 0| \equiv [1 \quad 0]$, or $\langle 1| \equiv [0 \quad 1]$, as the transpose of $|0\rangle$, or $|1\rangle$. The notation of "bracket" accordingly gives the formalism of: $\langle 1|1\rangle \equiv \langle 1||1\rangle$. By simple calculations, it is possible to note that identity operator *I* can be founded by an example as such: *I*= $|+\rangle\langle +|+|-\rangle\langle -|$ (Wilde, 2013). In any basis, accordingly, the identity operator *I* has the representation: $I \equiv \begin{bmatrix} 1 & 0 \\ 0 & 1 \end{bmatrix}$. Unitary evolution implies the reversibility by the logic of NOT gate as can be expressed through the formalisms as such: $|0\rangle \to |1\rangle$, $|1\rangle \to |0\rangle$ if the states of the 'closed system' are not measured. Accordingly, unitary evolution indicates the reversibility of the closed system that can be expressed through $U^{\dagger}U = UU^{\dagger} = I$. The Pauli matrices are among some of those other operators that are commonly used in the basic computations through quantum systems as: $Pauli - X \equiv \begin{bmatrix} 0 & 1 \\ 1 & 0 \end{bmatrix}$, $Pauli - Y \equiv \begin{bmatrix} 0 & -i \\ i & 0 \end{bmatrix}$, $Pauli - Z \equiv \begin{bmatrix} 1 & 0 \\ 0 & -1 \end{bmatrix}$ (Rieffel & Polak, 2011). The essential unitary operators that transform the computational basis to $+/-$ basis is Hadamard Gate: $H \equiv |+\rangle\langle 0| + |-\rangle\langle 1| = \frac{1}{\sqrt{2}}\begin{bmatrix} 1 & 1 \\ 1 & -1 \end{bmatrix}$ that operates as: $|0\rangle \to |+\rangle$, $|1\rangle \to |-\rangle$ (Rieffel & Polak, 2011).

Regarding the feature of entanglement in quantum information science, the most significant referential bases for quantum communication by entanglement are expressed in Bell states, as the ideal entangled states. Respectively, the four most well-known states of entanglement as Bell-states can be generated on X and Hadamard bases on Bloch Sphere, and they form an orthonormal basis $|\Phi^{+}\rangle = \frac{1}{\sqrt{2}} * (|00\rangle + |11\rangle)$, $|\Phi^{-}\rangle = \frac{1}{\sqrt{2}} * (|00\rangle - |11\rangle)$, $|\psi^{+}\rangle = \frac{1}{\sqrt{2}} * (|01\rangle + |10\rangle)$, $|\psi^{-}\rangle = \frac{1}{\sqrt{2}} * (|01\rangle - |10\rangle)$; as they can also be shown by the other bases: $|\Phi^{+}\rangle = \frac{1}{\sqrt{2}} * (|++\rangle + |--\rangle)$, $|\Phi^{-}\rangle = \frac{1}{\sqrt{2}} * (|-+\rangle + |+-\rangle)$, $|\psi^{+}\rangle = \frac{1}{\sqrt{2}} * (|++\rangle - |--\rangle)$, $|\psi^{-}\rangle = \frac{1}{\sqrt{2}} * (|-+\rangle + |+-\rangle)$ (Rieffel & Polak, 2011).

Thus, the formalisms of quantum information theory can even enable to superpose design entities together as $|ground, excited\rangle$ states, which actually make the quantum information theory and quantum technologies, such as quantum information processors or advances quantum computers as necessarily important here. As even considering structural elements under the quantum theory of gravity, the particular things as being a part of energy and information process by their entropies become highly relevant in that space. These projects can be seen as the solutions to make transitive compactifications among many iterations so that 4-dimensional experimental practices can be possibly constructed as well, while these cannot be simply seen as the magical solutions in themselves since it would only be a similar case of standardizing modular spaces that are gauged in the units of square meters or volumetric cubes.

■

Quantum technologies/applications: Quantum-based technologies can also be used together with new generation energy-efficient technologies such as quantum dots, semiconductors, and superconductors (Jager, Isabella, Smets, Swaaij & Zeman, 2014) following sunlight conditions. The potentials of satellite communication (Parks, 2012) to be thought with the development of photovoltaic energy panels (Jager, Isabella, Smets, Swaaij & Zeman, 2014) at a smaller scale provide some simple and basic understanding for the development at the housing scale. Such possibilities can also have the potentials to communicate with the larger scale geographical information systems (such as ‘rectenna’ systems) that are necessitated for developments of the sophisticated version of those solutions of photovoltaic panels for its energy-efficient systems (Jager, Isabella, Smets, Swaaij & Zeman, 2014; Aksamija, 2016; Yadav & Panda & Hachem-Vermette, 2020). Together with communication means, these systems can also be seen in the spaceflights and communication satellites (Parks, 2012; Smets et al., 2014; 2017).

Furthermore, beam splitters, interferometers, source, receiver, and signal transponders can be designed as structural systems (as a scalable project of NIF, for instance) or embedded within the structural systems (or even as a structural system in itself) yet with certain cooling issues as a next challenge. Then, they can be controlled by smart grids, nano, and microgrids as smart systems. The isolation of the optical features or the isolation of environments by architectural and architectonic elements can also be designed for hybrid systems of quantum traps and even with optical features (Figure 5.7). Once again, in advanced science, there are many different methods and approaches that try to solve similar problems. Reminding back the functionality and the level of abstraction in quantum equations not only in the standard theories but also in the advanced search (of Abelian, non-abelian, SU, SO3, SO4 equations/functions) (Becker, Becker & Schwarz, 2007), this can be seen as the only way to control the autonomous practice of architecture in advance.

■

Advanced Quantum-related inquiries in different fields: The eigenbasis of vectors and states of the cells can be discovered through spectral decomposition in the analysis and diagnosis of the eigen-cells of natural beings. There can be found some ways of (neural) diagnosis and symmetry of cells (brain lobes) with different functions at its initiation/birth. Beyond those non-material discoveries at wave functions and their probability space, these can also be discovered through the assumption of eigenvectors just to process information as a simulative action; there can be found some optical-photonic means of control and diagnosis. Their imagery and control, as well as other means of communication of other systems, on the other hand, evoke different innovation types. The question is how the ‘eigenstates’ and vectors of codes of design and environmental actions can also be revealed and processed similarly by the same logic. The eigenvectors of design action and eigenstates/values of design codes are crucial to be embedded into the algorithms of those interactions when the architecture and design culture are considered (vaccinated/hybridized with other cultures) together to be fertilized, grown, and evolve. In environmental interactions, some data is to be saved from the environment's corruption and noise by utilizing the universal circuitry of information processing with the decomposition of different variables and coherent data, discretely kept for those systematic solutions. Nevertheless, further advancements require more than necessary correlations that can only be founded through the entanglement of particles and special methods and technologies of controlling those special correlations. Information age's current capacities and capabilities enable the realization of other materialistic reality in the world of (networks of) super-positions. On the other side, the potential growth of (the right) technology can enable the true model for searching the imaginary in the super-symmetries, which can be observed as the actual.

The initial steps to explore the possibility between the actual technological capacities and the virtual design of tectonics and epistemological grounds of futuristic experiences of such 'Intelligence' also generate architecture's autonomous discourse that can be strong enough to decide on new technologies and means of production. Only the built environment can ground for such interactions of the natural and artificial agents. The discovery of the rates of gases and the possibility of liquid water in other planets observed via light beams and optical telescopes that are to be observed by observatories in the world can give the essence of robust feature recognition with the help of architectural growth. For the implication strategies that can be physically realized in such systems, the interactions between atoms and photons, and their values in the calculation and means of communication of the quantum information processing, become crucial to understand and evaluate the possible systematic solutions for those interactions.

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